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ABSTRACT

Five subdivisions comprise this volume. The introduction provides a brief overview of the history of the American Musicological Society. The next three sections review three symposia, the first of which--Musicology and the Computer I--was held in April 1965 and dealt with three of the major areas of computer applications to musicology: analysis, investigation of style, and documentation. The second symposium, held in May 1965 and titled Input Languages to Represent Music (Musicology and the Computer II) wrestled with the problems of translating conventional musical notation into machine-readable numbers, letters, and symbols. The final meeting, Musicology 1966-2000: A Practical Program, was convened in May 1966 and took a forward glance into the last third of the century. The fifth subdivision of the volume is a bibliography which contains some 617 listings of items published up through 1970 and which embraces all aspects of computer applications to music. (Author/PB)

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Three Symposia

Barry S. Brook, Editor

MUSICOLOGY AND THE COMPUTER

Musicology 1966-2000: A Practical Program

American Musicological Society/G.N.Y.C.

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Musicology and the Computer
Musicology 1966-2000: A Practical Program

Corrigenda

Page v., line 4	For William S. read William J. Mitchell
" 178, lines 24-25	Delete that as time. . . . interesting things
" 179, line 8	For Tone Music read Current Musical
" 179, line 19	For Ogden M. read Alexander Jones
" 179, line 23	For local read vocal
" 180, line 17	Delete Everything is a free format
" 181, line 10	For viability read variability

Regarding pp. 178-181: Apologies are due Mr. Michael Kassler for errors made in the transcription of his oral remarks in Symposium II and for inadvertently not sending him proofs thereof. (Ed.)

Page 193, line 12	For subsized read subsidized
" 273, line 21	For Ogden M. read Alexander

MUSICOLOGY AND THE COMPUTER
Musicology 1966-2000: A Practical Program

Three Symposia

AMERICAN MUSICOLOGICAL SOCIETY

GREATER NEW YORK CHAPTER

Publications

1. *A Programmatic History (1935-1965)* New York, 1965

2. *Musicology and the Computer: Three Symposia* New York, 1970

Barry S. Brook, Editor

MUSICOLOGY AND THE COMPUTER

Musicology 1966-2000: A Practical Program

Three Symposia

American Musicological Society
Greater New York Chapter
1965-1966

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Preface

This volume is dedicated to Otto Kinkeldey (1878-1966), whose vital role in the creation and growth of the American Musicological Society and of its Greater New York Chapter cannot be sufficiently acclaimed. Thus honoring a distinguished founding father--Kinkeldey was the first president of the AMS and first professor of musicology in the United States--is a rather routine procedure for political associations, rotarian brotherhoods, and scholarly societies. There is a unique appropriateness to the present dedication, however, given the unconventional character of the symposia recorded here; this may be seen from a paper Kinkeldey read before the Greater New York Chapter, of which only the following abstract has been published:

> The Music of the Future. A Phantasy.
>
> If the musician could be enabled to manipulate his sound effects as the painter handles his pigments, if he could mix his tones and overtones, his tone-colors and tone-shadings in infinite variety without the aid of... musical instruments, and if finally he could fix the resulting complicated sound curve upon a lasting medium like the sound film, capable of being acoustically reproduced at will with the aid of electric apparatus, he will have reached the autonomy and independence of the painter.... How soon a race of men accustomed to hearing music as we now hear it, with the intermediary interpreter ever present in the consciousness of the hearer, could adapt itself to a direct reception from the composer, is a difficult question.[1]

The date was March 22, 1936. It was his first talk to the chapter. Rather than "A Phantasy," a more fitting subtitle might have been "A Prophecy."

---

[1] See *Bulletin of the American Musicological Society*, No. 2, p. 3.

A word is in order about the background of each of the five subdivisions of this volume: the introduction, the three symposia, and the bibliography. All five grew out of meetings of the Greater New York Chapter, held under the editor's chairmanship during 1965-1966.

The *Introduction* by William S. Mitchell is the address he read as principal after-dinner speaker at the Thirtieth Anniversary Festivities of the G. N. Y. C. of the AMS. Professor Mitchell was president of the AMS at the time the thirtieth anniversary was being celebrated "with appropriate fanfare and mathematical inexactitude, a full thirty-one years after the Chapter's founding."[2] The "festivities" took place at the Harvard Club in New York on December 10, 1965. Guests of honor were Otto Kinkeldey, Gustave Reese, and Paul Henry Lang. This was Dr. Kinkeldey's last appearance in public. The late Noah Greenberg led the New York Pro Musica in an unforgettable concert of Florentine Medieval and Renaissance music. Mr. Mitchell's address is a witty glance backward over the thirty-one year history of our Society, 1935-1965. In this volume it serves as an asymmetrical counter-balance to our final symposium, which is a thirty-four year glance forward, *Musicology 1966-2000* , about which more below.

The opening symposium, *Musicology and the Computer I* , was, I believe, the first full-scale meeting of musicologists on the subject of computer applications, the first of many. It was held in the domed, appropriately contemporary Caspary Auditorium of the Rockefeller Institute (now University) on April 10, 1965, at the invitation of Theodore Shedlovsky, Professor of Physical Chemistry, distinguished scientist, and the Institute's Music Impressario Extraordinaire. One hundred and thirty chapter members and guests attended. The three speakers described work in three of the principal areas of computer applications to musicology: analysis, investigation of style, and documentation.

The second symposium, *Input Languages to Represent Music* (*Musicology and the Computer II*) , was a working conference attended by some thirty specialists

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[2] From the introduction to *A Programmatic History 1935-1965; American Musicological Society, Greater New York Chapter*, Barry S. Brook, ed., New York, 1965.

wrestling with the problems of translating conventional musical notation into available machine-readable numbers, letters, and other symbols. It was co-sponsored by the Automation Committee of the Music Library Association and held on May 10, 1965, at the I. B. M. Systems Research Institute in New York through the good offices of Stefan Bauer-Mengelberg, conductor, mathematical logician, and Mannes College president. The procedure adopted involved presentation of their input languages by several of the participants, followed by extended and sometimes rather heated discussion. The papers published here were in the main submitted afterwards. Some material has been distilled from transcriptions of the tapes made at the time. The contribution by Michael Kassler was not part of the original discussion, but was included by invitation of the editor because of its relevance to any survey of input methods. Mr. Kassler's paper is all the more remarkable since it was written in 1963, while he was a student at Princeton.

Symposium III, *Musicology 1966-2000: A Practical Program*, has a limited relationship to the computer. The diabolical machine *is* discussed briefly in several of the papers since it will inevitably play a significant role in musical research in the next three decades. This symposium was part of an all-day chapter meeting at Queens College on May 21, 1966, which also included three scholarly papers and a concert in memory of Noah Greenberg by the Queens College Collegium Musicum, directed by Paul Maynard. The symposium was conceived as a forward glance into the last third of the century by members of a society just about a third of a century old. Invited were six of the chapter's outstanding "younger" well-established scholars who would continue to influence the development of our discipline during those years, and whose prognostications may eventually be looked upon with admiration or amusement by their students, their colleagues, and themselves.

The fifth subdivision of the volume, the *Bibliography*, is not limited to musicology but embraces all aspects of computer applications to music. The history of its many metamorphoses is given on page 229f. It includes items published up to the middle of 1970.

A preface such as this, written three or four years after the fact, invites the addition of some well-chosen paragraphs of hindsight; I will resist the temptation. It is still too early to evaluate the contribution of the computer to musicology. The road is strewn

with aborted ill-conceived projects, with funding difficulties for well-planned ones, and with much duplication of effort. Despite the exceedingly slow progress in many areas, important work continues, and hope and promise abound.

Apologies are in order for the delay in the publication of this volume. Profound thanks are due to the many who made its appearance possible, especially Joseph Machlis, who by now has forgotten that he provided some of the funds to make the preparation of the typescript possible, and to Margaret H. Grupp, doctoral candidate at New York University, who put the finishing touches on the camera-ready typescript.

Barry S. Brook

Graduate Center
The City University of New York
June 1970

Introduction

A HITHERTO UNKNOWN--OR--A RECENTLY DISCOVERED...

William J. Mitchell

(Remarks delivered on December 10, 1965 at the Harvard Club on the occasion of the Thirtieth Anniversary of the founding of the Greater New York Chapter of the American Musicological Society.)

When Mr. Brook planned this delightful dinner and fine concert there was some question of how many would attend. We foresaw no serious trouble with the elders of our Society. They have lived through decades when banquets were rare and the table scant. A good meal for a good cause was sufficient enticement. It was the young who were a cause of concern. Fat, blasé, well travelled, as a result of benefits from various branches of the Rockefeller family, the Ford and Guggenheim foundations, there was real doubt whether ample providance and the promise of a rare concert would prove sufficient lures. Obviously it has, and the more so because we have caught them by a stroke of good fortune between leaves of absence, voyages to the ends of the earth, and tightly scheduled sessions in the laboratory. May I welcome all of you to tonight's festivities; the elderly and lean, the middle aged and bewildered, the young and machine-fed.

In addressing you tonight, I do not wish to pose as an official chronicler of activities that have occurred in the lifetime of most of us. There are others far better qualified to take on this enviable assignment. However, certain highly important documents have been placed in my hands by Gustave Reese, and the files of the NYAMS, as well as an advance copy of the adroitly assembled "Programmatic History" have been delivered to me by Barry Brook. In addition, I have my own treasured memories. I shall call on all four sources in speaking to you informally about our prehistory and our written and unwritten history.

Before engaging you in these matters let me state my credentials, recorded in what is for me the most important document of all, a letter written under the caption

American Musicological Society and dated August 30, 1939. It reads, in part: "My dear Mr. Mitchell, I take pleasure in notifying you that you have been elected to membership in the American Musicological Society. I enclose herewith a copy of the Constitution and By-laws for your information. Dues ($3.00) should be sent to the Treasurer, Dr. Paul H. Lang, Music Department, Columbia University, 116 Street and Broadway, New York, N.Y." There is a second paragraph to which I shall refer presently. The notification is signed, "Very sincerely yours, Gustave Reese, Secretary." Briefly, I was not on the musicological Maiblume, but I had fine and distinguished companions, for similar letters were sent at about the same time to Gilbert Chase, Max Graf, Ernst Krenek, Hertha Schweiger, and Leo Schrade.

Let us proceed to the prehistory, recorded in Bulletins #1, 2, and 3 of the New York Musicological Society. Bulletin #1, dated November, 1931, states, in part,

"A small group of men interested in the rapprochement of science and music met on the evening of January 29, 1930, with the purpose of organizing a purely local society. There were present Mr. Cowell, Dr. Kinkeldey, Mr. Schillinger, Mr. Seeger, and Mr. Yasser. A committee was informally drafted to report upon the matter of permanent organization and the date of the first meeting was set for February 19th. The committee--Messrs. Cowell, Yasser, and Seeger, (Chairman)--advised the temporary postponement of formal organization. The following general principles were agreed upon:

1. The membership should be small, comprising only men of active musicological interest as shown either in publication, achievement, or in the reading of a paper by invitation.

2. Guests might be introduced, but they should be expected to contribute to the discussion.

3. Each meeting should be devoted to the reading of a paper, no member reading again until all the others in turn may have contributed. After the reading of the paper, each member and guest present should comment in turn and after the speaker's rebuttal, general discussion should be held.

4. Occasional meetings should be given over to "round table" discussions upon predetermined subjects, each member and guest present being expected to give in turn a prepared statement of from five to ten minutes duration, with general

discussion following.

5. Chairmanship for the evening (to keep the discussion from wandering away from the subject) should rotate informally among the members.

An interesting question comes to mind in connection with Article 3. Was the added clause intended to provide an organizational rule to encourage the members to speak or to force them to remain silent? The following sentence provides us with a helpful clue: After the reading of the paper, each member and guest should comment in turn and after the speaker's rebuttal, general discussion should be held. And the clinching evidence is provided by a later remark: Meetings...were held at the residence of Mrs. E. F. Walton who invariably provided refreshments some time after midnight. Evidently volubility reigned, and would not suffer dethronement.

Bulletin # 2, covering 1931-32, contains vital material related to certain points that I want to stress later.

An Executive Committee, consisting of Henry Cowell, Joseph Schillinger, Joseph Yasser, and Charles Seeger, Chairman, helped in the drafting of a Constitution and By-Laws. The Constitution contained 8 Articles and 5 By-Laws, from which I should like to quote a few statements, briefly.

Article 3 defines two classes of membership: Active, both resident and non-resident, and Associate. From the By-laws we learn that the Active resident members were to pay $3.00 in annual dues, the active non-resident members, $1.00. These classes were entitled to one vote at the Annual Meeting, provided they were not in arrears. Associate members had no vote, but their financial obligation was the subscription to the Society of any amount not less than $5.00. What were the qualifications for the privilege of paying at least $5.00? Simply an evidence of interest in such work as might be done by active members. Article 6 provided for the dissolution of the Society, and Article 8 for the disbursing of assets upon dissolution.

Bulletin # 3, covering 1933-34 and a new series, Bulletin # 1, dated June, 1936, of an upstart group, called the American Musicological Society, provide us with the final chapter in our prehistory, and the meat of our inquiry.

Here are certain, unsettling facts, culled from the record:

1. In March, 1934, a Dr. Harold Spivacke was elected Secretary and charged with

the special task of formulating a basis on which a National Musicological Society could be founded.

2. On June 3, 1934, the New York Musicological Society, through its chairman and in accordance with Article 8, declared itself dissolved. A more complete account is given in Bulletin # 1 of the AMS.

3. "On June 3rd, 1934, nine people--George Dickinson, Carl Engel, Gustave Reese, Helen Roberts, Joseph Schillinger, Charles Seeger, Harold Spivacke, Oliver Strunk, Joseph Yasser--met at the apartment of Mrs. Ernest F. Walton, at 25 Washington Square North, New York, and declared themselves The American Musicological Association. Otto Kinkeldey was elected President. At a further meeting (September 15th, 1934) the name of the association was changed to American Musicological Society. At a general meeting, held on December 1st at the Club Rooms of the Beethoven Association, a constitution and by-laws were drawn up and officers elected: Charles Seeger and Oliver Strunk, Vice Presidents; Gustave Reese, Secretary; Paul Henry Lang, Treasurer, as well as an Executive Board including these officers and four members at large: Jean Beck, Archibald T. Davison, Carl Engel, Carleton Sprague Smith.

4. "The Chapters of the Society were formed as follows: Greater New York Chapter, January 15, 1935, at the Club Rooms of The Beethoven Association. Officers: Joseph Yasser, Chairman; Gustave Reese, Secretary. Julius Mattfeld was elected Treasurer at a later meeting."

Who was this Dr. Harold Spivacke? Observe that in 1934 he was appointed assistant Chief of the Music Division of the Library of Congress. Was he charged by his superiors in Washington with the execution of a secret, callous operation? Was it his assignment to wrest from New York City its own Society and federalize it? Was this bureaucracy on the move? Who was his superior? A certain Oliver Strunk, now teaching at a rural institution situated in New Jersey, midway between New Brunswick and Trenton. The "nine people"--were these the nine who, once their work was done, were referred to cynically in Washington as "the nine old men"?

But that's not all. Note that the New York Musicological Society was dissolved "in accordance with Article 8." But Article 8 does nothing more than describe the distribution of assets of the dissolved Society. Article 6 describes the procedures

of dissolution. I do not mean to place the taint of embezzlement on the Executive Committee. Anyway, there were not enough funds in the treasury, in all probability, to buy a copy of Drdla's SOUVENIR. No, not embezzlement, but simply curious irregularities from a New Yorker's point of view.

Finally, did you observe that the "nine people" did not include Dr. Kinkeldey? I have it from one of the members who was present on that fateful night that he was deliberately frozen out. Why? So that he could be drafted for the Presidency, which he was, regardless of his wishes.

Why do I burden you with all of these details, questions, insinuations? Mr. Brook, the New York Musicological Society, it seems to me, was never dissolved legally and officially--it lives on tonight. Hence we are in all probability celebrating our 35th, not our 30th anniversary. Gentlemen, and, if you wish, Ladies, we may be older than we believe. Think about it, anyway.

Well, it's all done now! From here on written and unwritten history give us a somewhat clearer picture.

Before I go into the records, let me remind you of what it was to be a musicologist in the 1930's. Of institutionally recognized musicologists, there was only one with the official title, Professor of Musicology, in the 30's, and that was Dr. Kinkeldey. But he had to double as University Librarian. Professors Lang and Reese did not make it until the 40's. Most musicologists had to settle for librarianships and teaching posts, often in other fields, such as history, as Drs. Smith and Strunk may recall. Or they found positions as organists, as Dr. Yasser will recall.

In the popular mind, a musicologist was thought of as some kind of cross between P. T. Barnum and Beckmesser--another of the posturing "ologists" who dot the American historical landscape. When I confessed to my friends and relatives that I wanted to be a musicologist, invariably they would look at me, studiously, and remark; "You don't look like a musicologist." This was the social arena in which the New York Chapter led its existence in the 1930's.

Because you have before you a carefully assembled "Programmatic History," which covers the main course of events from the beginnings of the New York Chapter to the present, it will not be necessary for me to dwell on recorded history, except to make a few brief remarks. Note, especially in the earlier years, the variety and

frequency of ethnomusicological speakers and topics. And, as you might expect, historical musicology has been centrally featured over the years. But observe the broad spread of topics--Theory, both historical and speculative, acoustics, electronic music, music education, instrument building, computerized research, and, more recently, moving day problems.

Observe also the number of distinguished foreign speakers--I have counted thirty in 30 years. Some returned to their native lands, some remained here, and others settled in the suburbs, such as Massachusetts, Illinois, Texas, and California.

Especially to be noted, are the outstanding composers and performers who have participated in our meetings. I spotted, among others, Béla Bartók, Paul Hindemith, Darius Milhaud, Arnold Schoenberg, William Schuman, Roger Sessions, Edgard Varèse, along with Rudolph Kolisch, Edouard Steuerman, Otto Klemperer, Artur Schnabel, Fritz Stiedry, Leopold Stokowski.

I exclude from this list those composers and performers who have been continuously and actively identified with the New York Chapter. These must include Suzanne Bloch, Ralph Kirkpatrick, Arthur Mendel, Yella Pessl, Henry Cowell, Alfred Mann, Noah Greenberg, and Denis Stevens. The list could easily be expanded.

The index to "A Programmatic History" will prove useful. According to individual interests, additional items may be entered. I have one to suggest. If you have your pencils and index cards with you, jot down pages 2, 4, 8, 9, 10, 14, 15, 20 to follow a new entry, "Financial vagaries". I will recite only one: On page 20, covering 1956-57, we note the whimsical statement; "Dr. Kinkeldey (Chairman) made the usual, annual plea for funds." The statement suggests a long history of insolvency, but note one cheering indication. The plea was now being made only annually. Earlier it had been made monthly. This gaves me the opportunity to read the second paragraph in my notification of admission:

"At the Annual Business Meeting held in Washington December 30, 1938, it was voted that the Treasurer be authorized to assess members $1.00 each during the course of the year, should extra funds be needed to make possible the publication of the Bulletins of abstracts for both 1937 and 1938. The 1937 Bulletin has already been published, but extra funds are needed to publish the one for 1938. Will you please regard this as a notice of assessment of $1.00 and add that sum to the $3.00 mentioned

above."

Written history in the form in which you have it in A Programmatic History should prove interesting reading. Before closing tonight I should like to add a few details from the unwritten history as remembered by one who was there. To start with, the meetings, judged from today's standards were long, and the discussions highly animated and loquacious. On more than one occasion in the 30's discussion as such was interrupted by the unsolicited reading of unscheduled, but carefully prepared and lengthy papers by individuals who gained the floor simply by rising and speaking. The subjects of these papers were usually related in no way to the announced topic of the evening. But everybody listened.

On one occasion Dr. Edward Dent, while reading a paper on opera, mentioned, in passing, the role of the chorus in 17th century Italian Opera. He had scarcely completed his statement when a well versed American Handelian rose and said firmly: "There are no choruses in Italian operas." Dr. Dent acknowledged that there were no choruses, that he really had in mind ensembles of the Principals, which functioned as a chorus. The rejoinder was: "There are no choruses in Italian operas." So far as I can recall this is the closest that the American Musicological Society ever came to an international incident.

There was one meeting at which a young articulate member addressed himself to the decadent state of music criticism. He singled out one particular music critic for his most flamboyantly phrased attack. It seemed to make little difference to him when it was pointed out quietly that the critic happened to be in attendance that evening. As I understand it, they later found reconciliation or, to put it musicologically, they buried the hocket, and through a curious irony, the critic of the critic became himself a critic--one of New York's finest.

The meetings did not terminate with our expulsion, usually close to midnight, from the Beethoven Association or Schirmer Hall, for they were invariably resumed at the nearest Childs Restaurant over coffee and assorted foods. In these sessions the range of topics was unrestricted; they were brought up successively or, more usually, introduced simultaneously. Let me single out only one discussion, for me a memorable one. Two eminent theorists of Russian ancestry embarked on a prolonged and heated review of the systematic theory of one of them. The author

claimed, in the course of the evening, that his methods of stylistic inquiry and composition were so completely scientific and thorough that he could, without any difficulty write a Symphony undistinguishable from Beethoven's. This statement provoked a spirited argument that reached a climax at about 2:30 a. m., at which time the author was asked, "Why don't you write such a Beethoven Symphony ?" The answer, which brought the evening to a close, was: "Why should I, we already have nine of them."

In our native past there is a fabled baseball team, famous for its aggressive, relentless, expert type of play. It consisted of such stars as Dizzy Dean, Daffy Dean, Muscles Medwick, Pepper Martin, and Frankie Frisch, the Fordham Flash. Officially, they were known as the St. Louis Cardinals, but unofficially they had a special name which I shall reveal in a moment.

Otto Kinkeldey, Paul Lang, Gustave Reese, Carleton Smith, Arthur Mendel, and those others of the 1930's who by their relentless, aggressive, uncompromising activities in the field of scholarship nurtured a society, and in particular, a chapter which, in my opinion, have no rivals, may I salute you on this festive occasion as our revered musicological Gashouse Gang.

SYMPOSIUM I

MUSICOLOGY AND THE COMPUTER I

Symposium, April 10, 1965, Rockefeller Institute

THE STRUCTURE OF ATONAL MUSIC: PRACTICAL ASPECTS OF A COMPUTER-ORIENTED RESEARCH PROJECT

Allen Forte

Introduction

This paper describes briefly the essential features of a computer-oriented research project which is now in its initial stages. Within the confines of this sketch I will endeavor to be as specific as possible, in order to indicate certain practical aspects which may be of interest to the scholar who contemplates extensive use of the machine.

The project is concerned with a structural description of the revolutionary and enigmatic non-tonal music of Schoenberg, Berg, and Webern composed during the period 1908-1923, so-called atonal music. Essentially, the project has three parts. The first of these comprises the working-out of basic theoretical formulations which may be useful in the development of an explanatory framework. The second encompasses analytic method: the establishment of procedures for examining and interpreting data. The third entails the testing of structural descriptions by techniques of reconstruction.

The computer is being used extensively for all three phases, since a project of this complexity requires the accurate processing of a large amount of information, a task virtually impossible to carry out by hand methods. It should be pointed out that the term computer refers to a high-speed data processing system, which includes input and output devices. The system presently being used in this project is the IBM 7040-7094 Direct Coupled System installed at the Yale Computer Center.

To illustrate the role of the machine, I will give brief accounts of two of the computer programs which have been executed successfully in connection with the project.

A Program to compute the set-complexes

A computer program is an ordered list of instructions which generates a sequence of machine operations in order to achieve a specified result. The first program to be

described was designed to assemble sets of related pitch-collections called set-complexes[1]. It is thought that these arrays may be useful in the description of relations characteristic of atonal music.

At a primitive level, the pitch organization of an atonal work can be described in terms of discrete pitch-collections, or pitch-sets. Each such collection can be regarded as a representative of a class of sets defined as equivalent on the basis of interval-content. For example, the collection (C, D, E) belongs to the same class as the collection (G, B, A). If we have two pitch-collections M and N, where M ⊃ N, it is possible that M may contain all the elements of N. For example, if M is the set (C, D, E, F#) and N is the collection (C, D, E), we say that M contains N (or, M is the superset of N). We can also say that N is a subset of M. This familiar relation, the inclusion relation, provides a basis for assembling the set-complexes of the 12 pitch-class system. The most interesting type of set-complex is the complex about M and N, where M and N are complementary with respect to pitch-content, and where the complex comprises only those sets which are both supersets of N and subsets of M. The characteristic symmetry of the 12 pitch-class systems reduces the number of such distinct set-complexes from 220, corresponding to the 220 distinct pitch-sets, to 135.

A set-complex can be compiled from lists of subsets and supersets, each entry in the list representing an equivalence class. Example A shows part of a list of inclusion relations in the form of a matrix. Observe that the matrix contains only entries of zero and one. A one means that the inclusion relation obtains; a zero means that it does not. For example, to find the 3-element supersets of Set 2-1 (the collection which forms the interval of a minor second), the first row of the array is examined. Whenever a one is encountered an entry is made in an array which represents the set-complex about Set 2-1 and its complement, Set 10-1. When all the 3-element supersets of Set 2-1 are found, their supersets containing 4 elements are located and additional entries are made in the set-complex matrix. Example B shows the set-complex about the hexachord numbered 6-10, a prominent set in the Webern composition to be discussed below (Examples C and E).

[1] Allen Forte, "A Theory of Set-Complexes for Music". Journal of Music Theory, VIII/2, Winter, 1964, p. 136-183.

EXAMPLE A

PART OF ARRAY MTRX

```
111110000000
110001111000
011000100110
001101010011
000110101010
110000
111000
101100
100110
100011
010100
011010
010101
010010
001001
001110
000100
```

EXAMPLE B

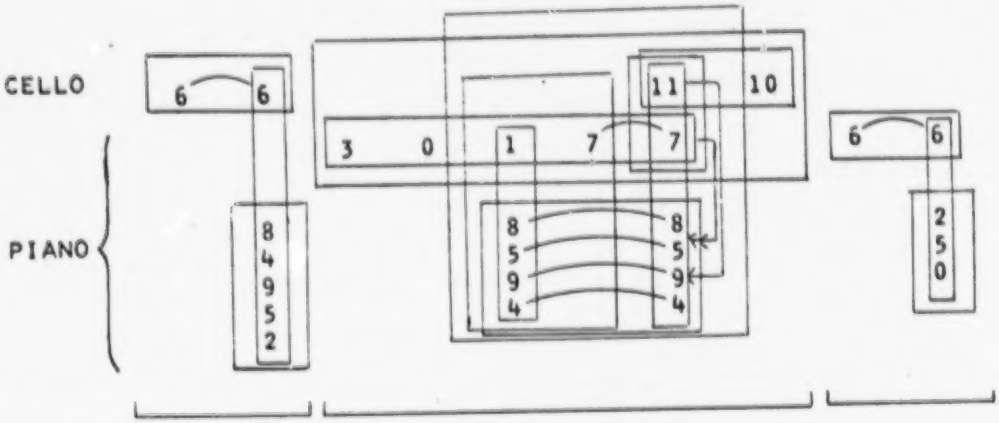
SET-COMPLEX ABOUT (6-10)

```
111111000000000000000000000000000000000000000000 6
111111111110000000000000000000000000000000000000011
011100100011010111001100000010000000000000000000013
001000010010000101000001000000000000000000000000 6
000000000000000000000000000000000000000000000000 0
```

EXAMPLE C

WEBERN: OP. 11/1, BARS 1-3

ENCODED COMPOSITIONAL SETS



The total execution time for the set-complex program, including both printed and punched-card output was 1.94 minutes. For each complex the total number of components was computed, as well as the number of component sets of each size. The latter are shown in the rightmost column of Example B. The punched-card output alone, a total of 945 cards, would justify the use of the machine. These cards will be used as input data for a program to determine the differences and similarities between set-complexes.

The matrix format of both input data and output was designed to take advantage of certain features of the computer language used, the Michigan Algorithm Decoder, commonly known as MAD[2]. This language handles logical statements with facility and has a number of other attributes which make it suitable for work of this kind.

A Program to identify compositional sets

The accurate identification of pitch-sets in an atonal work is an essential first step in analysis. This is a more complicated task than in the case of tonal music,

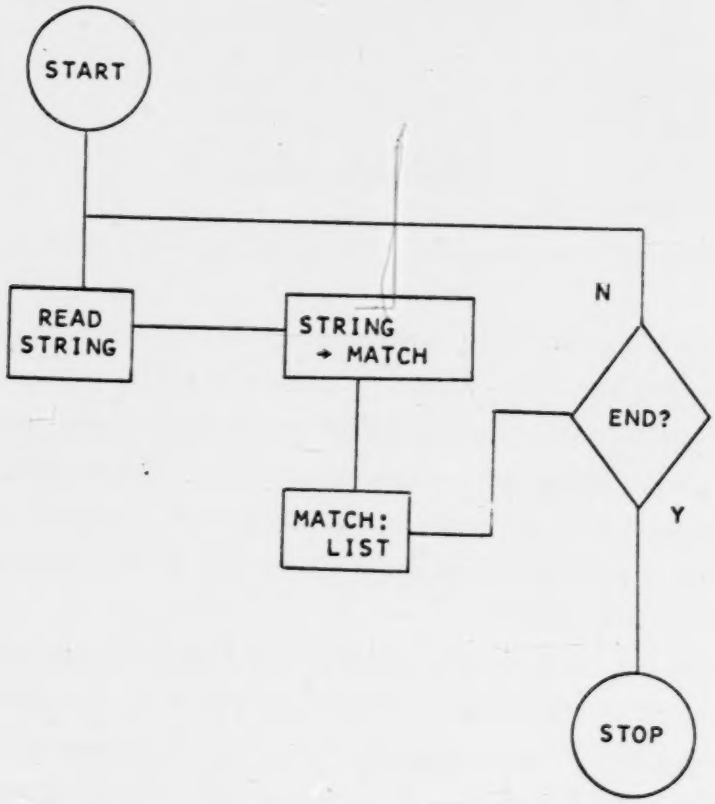
[2] B. Arden, B. Galler, and R. Graham. Michigan Algorithm Decoder, The University of Michigan Computing Center, 1964.

for atonal compositions may employ any of the 220 distinct pitch-sets, whereas tonal music employs approximately 25.

EXAMPLE D

SET-IDENTIFICATION PROGRAM

SIMPLIFIED FLOW DIAGRAM



There are certain practical difficulties involved in the preparation of input data for the set-identification program. These center around the delimiting of compositional units and the sets which they contain, and the encoding of the pitch-sets for punched-card input. The solution lies in the establishment of rules for encoding. At the present stage of the project provisional rules have been set up to cover as many relevant cases as can be foreseen, based upon experience with the music. For example, the character-

istic juxtaposition of equivalent sets in vertical and horizontal statements taken into account when Webern's compositions are encoded. At a later stage, when the rules are stabilized, it will be possible to utilize an input language for internal representation of the score. This, in turn, will permit programming of the encoding procedure, that is, automatic encoding. A further step, but one which is not economically feasible at present, is to use an optical reader, thus eliminating hand work altogether in this clerical operation.

The symbols employed in encoding are selected for economy and for flexibility in subsequent processing. For the set-identification program, compositional sets are encoded numerically, the 12 pitch-names of the equal-tempered scale degrees being placed in 1-1 correspondence with the set of positive integers (0, . . . , 11). To illustrate the procedure, an encoded portion of Webern's Three Pieces for Cello and Piano, Op. 11, is shown schematically in Example C. The boxes enclose 15 compositional sets, covering all configurations thought to be of possible interest. The brackets at the bottom of the example show the extent of each unit, roughly, a "phrase".

The integers for each set are punched one to a card, in any order. The resulting deck is read in as data, together with a deck of cards containing integer-sets representing the 220 distinct pitch-collections in optimal normal order, the most "condensed" form of the set. The program processes one set at a time, first arranging the set in optimal normal order. The matching set in the list of 220 is then located and the set-identification number is printed, together with a variable number of other characteristics. Example D shows a greatly simplified flow diagram of the program. The names STRING, MATCH, and LIST do not refer to household items in this instance, but are names given to specific segments of stored data. STRING contains the compositional set currently being processed; MATCH is the optimal normal order of that set; LIST is the list of 220 distinct pitch sets. "READ STRING" means to store the next segment of data called STRING, that is, the next set to be identified. The arrow in the second box means "becomes", and the colon in the following box means "compare". "END?" requires a decision: Have all the sets been processed, or should the program continue?

EXAMPLE E

RESULT OF SET-IDENTIFICATION

PROGRAM (WEBERN: OP. 11/1, M. 1-3)

ENCODED SET	SETID	VCTRS	UNORD
6 8 4 9 5 2	6 10	333321	4
11 10 3 0 1 7 8 5 9 4	10 4	888984	4
3 0 1 7	4 29	111111	5
11 10	2 1	100000	1
8 5 9 4	4 7	201210	3
1 8 5 9 4 7 11	7 26	344532	4
3 0 1 7 11 10	6 39	333321	4
11 7 8 5 9 4	6 10	333321	4
1 8 5 9 4 7	6 15	323421	5
1 8 5 9 4	5 21	202420	4
11 7	2 4	000100	4
11 8 5 9 4	5 18	212221	4
7 8 5 9 4	5 3	322210	4
3 0	2 3	001000	3
1 7	2 6	000001	5

Example E shows the result of the set-identification program for the Webern excerpt represented in Example C. From the raw input data, shown on the left, the program has provided the information given on the right. In the first column on the right, under SETID, is the identification number of the set. The next column shows the interval-content of the set in a vector notation, where the first component is the number of minor seconds, the second component the number of major seconds, and so on, for the six interval-classes. The third column, under UNORD, represents the order of intervallic uniqueness. For example, the integer 4 in the first row means that four

successive components must be compared left-to-right with the corresponding components of all other vectors before the vector is unique. This provides a simple measure of the distinctiveness of a collection. For this program the total execution time was 20 seconds.

A detailed analysis of the output is not possible here. I point out only one feature of interest, one which might not be apparent in a less comprehensive reading of the sets. The composition begins with an isolated statement of Set 6-10. As shown in the example, this set subsequently is stated together with Set 6-39, a set which has the same interval-content as Set 6-10, but which is not inversionally-related to it. The significance of this and other set-relations must await the development of an adequate and general structural description of atonal music.

The program can also provide information about set-transformations (for example, transpositions and inversions) and about order-characteristics. Thus, from a basic and simple program one can begin to refine an analysis and to extend its scope far beyond the capabilities of hand methods.

It should be remarked that the set-identification program, even in its simplest form, could yield information which is not available at present. It could be used, for example, to compile a dictionary of sets used by individual composers. A dictionary of this kind might well suggest specific lines of historical development.

Prospectus

Competence in the field of inquiry remains the basic requirement for intelligent and productive use of the computer. The formulation of problems and the interpretation of machine output obviously condition the ultimate results of computer-oriented research. Perhaps not so obviously, the use of the machine influences both the choice of research problems and the structuring of methods for the investigation of those problems.

The study of musical structure with the aid of computer programs offers many interesting possibilities which transcend the routine. One can program, for example, to test hypotheses of syntactic structure, to sort for combinations of characteristics in various environments, and to condense the results of such processing in order to reduce the amount of irrelevant output. Different uses of the machine for musicological

purposes probably will entail programming in languages with special attributes--for example, the powerful language LISP, for symbolic data processing, or the list-processors SLIP and SNOBOL[3]. The development of such languages, together with the remarkable technological resources being made available, offer an exciting vista to the present generation of scholars.

[3] John McCarthy et al, LISP 1.5 Programmer's Manual. M.I.T. Computation Center, 1962. J. Weizenbaum, Symmetric List Processor, Communications of the ACM, 6/9, 1963. D. J. Farber et al, SNOBOL, a String Manipulation Language, Journal ACM, 11, 1964.

A STYLISTIC INVESTIGATION OF THE MASSES OF JOSQUIN DESPREZ WITH THE AID OF THE COMPUTER: A PROGRESS REPORT

Lewis Lockwood

If I open this progess report by reporting moderate progress, I do not mean in doing so to minimize the tasks of preparation and groundwork that have been accomplished so far in this project. Yet since a good deal of current discussion of this subject often takes the form of speculation on a broad range of potential uses of computers in musicology, or else is devoted to a defense of one side of the controversy often waged over the alleged propriety of such uses--it seemed most useful to limit these remarks to a factual description of the project now being developed at Princeton under the joint direction of Professor Arthur Mendel and myself: an investigation of some stylistic properties of the Masses of Josquin Desprez with the aid of the computer. If the moral of this tale turns out to be identical with that of the tortoise and the hare, then perhaps this account may prove to have been of some small value to others interested in similar applications. Beyond this, many of the problems of formulation and procedure that have so far arisen in this project, have been and are being dealt with, so far as I know, for the first time, and are potentially applicable to studies of other repertoires. I have in mind here the formation of encoding languages for transferring musical notation to the computer and the writing of the programs needed to manipulate the material and to produce as intelligible output the answers to questions about the music thus stored in the computer memory.

The project is collaborative in the widest sense, and both Professor Mendel and I have been essentially the beneficiaries of the knowledge and talents of a number of graduate students and research assistants in the Music Department at Princeton, especially Michael Kassler, Tobias Robison, Hubert Howe, and Eric Regener. Both they and we have been able to give only part of our time to the project over the year and a half of its existence; but it is almost entirely due to their backgrounds in computer

programming and machine languages, which each had acquired before coming to Princeton or has acquired since, that we have made such progress as we have. The residue of that "almost" is our indebtedness to the University Research Board and to the Rockefeller Foundation for financial support. We have also been the beneficiaries, in an unexpected way, of another project harnessing computers for music, now being carried on at Princeton by our colleague Professor James Randall, together with Godfrey Winham and Messrs. Robison, Howe, and Regener: the use of the computer as a tool for sound-generation and electronic composition, as well as for the study of musical perception.[1] The immediate result here has been the production of a series of electronically generated "performances" of portions of some of the Josquin Masses (and eventually all of them) not merely as useful representations of the pieces in audible form but as a way of "proofreading," of controlling the accuracy with which the works have been translated from conventional notation to the computer-acceptable notation we have been using.

The project was originally conceived as a pilot study to try out the possibility of using the computer to test a variety of theories about musical structure in a limited group of works closely related to one another. We began with the Masses of Josquin primarily because both Professor Mendel and I happen to be interested in the composer and in various aspects of the music of this period, and also because the Josquin Masses form an obviously important and reasonably homogeneous group of works available in a standard critical edition. This choice was also dictated partly by calculating the time and labor that would be involved in translating the musical notation and texts of the Masses and their models into a computer-acceptable notation by manual key-punching. The 22 complete Masses and separate movements published in the Smijers edition cover some 600 printed pages of music, and the most optimistic estimate was that this would require some 800 hours of keypunching (not to mention proofreading) to be carried out by paid student keypunchers armed with patience, fortitude, and a modicum of musical literacy. Actually the laborious tasks of keypunching, even divided among many hands, have gone at an uneven pace, and we have

[1] See J. K. Randall, "A Report from Princeton", Perspectives of New Music, Spring-Summer 1965, pp. 84-92 (published after this talk was given).

learned valuable lessons about human frailty in discovering how difficult it is to achieve a letter-perfect representation of any body of music, free of errors large and small. We have also learned the same lesson about the Smijers edition itself, both in the process of keypunching and by means of programs written to check certain aspects of the notation. Without denigrating in the slightest the monumental achievement represented by the edition, I can report that Mr. Howe has written a program to check whether all measures in a group of Masses thus far keypunched contain the proper number of durational units in each measure following a given time-signature--and has produced a fair-sized list of errata traceable to errors of transcription or typography in the Smijers edition; errors which I have never seen referred to in any review, by the way. At all events, the great majority of the Masses are now keypunched in their entirety, and most of these have been proofread, while the remainder are near completion; with the help of the electronically generated "performances" mentioned earlier we expect to re-proofread the whole group once again.

To make the major steps accomplished so far as clear as I can, let me briefly recapitulate what they have been and who has made them. The original impetus to the whole project came from Michael Kassler, who has not only made fundamental contributions to the entire process of utilizing the computer for musical investigation, but whose persuasive powers first encouraged us to think that computers might indeed be of great and potentially revolutionary use in a number of musicological tasks. Mr. Kassler wrote the first of three different input languages that have been developed in this project; he conceived the programming language for Music Information Retrieval (MIR) within which questions concerning configurations of notational elements can be constructed as programs; and he, and especially Mr. Robison, have done the major share of work towards perfecting the complex nest of routines that will make it possible to convert the current input notation into a notation that can represent for each note the information wanted in the terms desired: the voice to which it belongs, its pitch, register, diatonic note-class, duration, and attack-time within the measure.

A second input language, called Intermediary Musical Language (IML) has been developed by Hubert Howe and Alexander Jones of the University's Computer Center, and this is the language that has been used to encode all the music thus far keypunched. Still another language, built along different lines, has been constructed by Eric Regener:

this is called Linear Music Transcription (LMT). These languages are similar in their capacity to represent large numbers of notational characteristics as symbolic data; they differ in the ways in which they organize the characteristics transcribed, and also in their relative sophistication concerning matters of detail (such as ties and slurs), and the kind of conventional musical notation for which each is best suited. IML is useful for polyphonic music in which, as in the Josquin Masses, the respective lines are notationally distinct and each polyphonic part contains only one note at a time: it would not be able to handle music in which the individuation of lines is more complex and difficult, such as keyboard music in which changing numbers of simultaneities may occur within a piece in a single staff. For transcription of such music LMT would be more suitable.

Coincident with keypunching the music into IML, work has been done, though it is not yet finished, towards assembling and perfecting both a conversion program (to "convert" a composition written in IML into a representation of it on magnetic tape) and the system of programs written in the newly-created macro-language (MIR) which, when completed and running effectively, will make it possible to obtain in intelligible form the answers to programmed questions about any aspects of the structure of the compositions that have been represented in the language. The principal work on the "debugging" of the MIR programs has been carried out by Mr. Robison; it is near completion, and when it is ready, a steady flow of answers to interrogations about the material should be forthcoming.

I alluded earlier in quite general terms to some of the sorts of problems about which questions are being submitted, and I should like to comment further on these here. Let me add, parenthetically, that I am very far from claiming or implying that the only types of questions about these works that are important are those for which answers can be elicited in this way--or that the answers so elicited are either inherently important in themselves, or attain importance by being so elicited. Only too obviously, the potential danger of such a procedure lies in its making it easy--or at least look easy--to ask questions about music that bear little or no significant relationship to what we intuitively value in individual works or to any important historical or theoretical conceptions we entertain about them. To this the only answer is that having a computer is no substitute for having an idea; that there

appears to be no end of trivial questions, and questioners; and that the danger is equally potent for mechanically-minded musicologists who have nothing to do with computers--as also for any other field of enquiry. Perhaps the main potential value of this procedure lies in its application to those problems and clusters of problems that may shed new light on the material under study, but for which it would be painfully arduous, inefficient, and unrewarding to assemble the answers by manual means. It scarcely seems Utopian to think that with the aid of a tool whose primary virtues are speed, accuracy, and tirelessness, we may be able to significantly enlarge our understanding of detailed aspects of musical structure in ways that may not only deepen but alter our understanding of those larger dimensions that do lie within our intuitive grasp. And a salutary by-product of this procedure is that the logical organization of computer investigation not only invites us but compels us to frame our small-scale questions in precisely defined terms, and thus to formulate our large-scale problems in ways more exact than seems likely to be the case if we were merely making tentative steps towards answers that in large measure appeared to be hopelessly beyond reach.

Among the problems for which programs are being, or will be, prepared, are those concerning the occurrence, order, and correlation of specific linear, harmonic, contrapuntal and rhythmic configurations in these works. For any one of these in early polyphony, not to mention the areas of text-setting and declamation, the presently unknown determining conditions outnumber the known. Regarding linear structure, for example, we have on the one hand a large body of contemporary theoretical writing in which the modes are defined not only as octave-species abstractions but as differentiated types of linear motion, collections of motivic units that move within pre-determined spans; and we have on the other hand a group of works that offer certain superficial clues to modality--for instance, in their signatures, part-ranges, choices of final harmonies, internal cadential degrees--and even at times in their titles, such as that of the Mass L'homme armé sexti toni. Yet we have as yet no very precise understanding of the degree to which the linear patterns of these works, in all their subtle ramifications, correspond to such descriptions of modality as we find in the theorists, or the degree of similarity or difference that distinguishes any pair of works that appear to be modally related. Nor can we claim to know,

although some believe, that in polyphony of the period the older systematic distinction between the plagal and authentic forms of the modes is truly devoid of meaning: the question would seem to depend on the relative emphasis given to one or another segment of the total ranges of the voices (the tetrachords and pentachords of the modes), and again the compilation of detailed information of this kind is a task one would gladly turn over to a computer, but of which the results may be wholly unexpected. Consider, too, still in the linear domain, that it is now more than forty years since Knud Jeppesen (at the Basel Congress of the IMS in 1924)[2] announced for the first time his observation of a peculiarly minute regularity in the music of Palestrina: the virtually complete absence of any upward leap from an accented quarter-note in the usual mensuration of tempus imperfectum. What gives this seemingly trivial detail importance is that Jeppesen was able to incorporate it into an exhaustive codification of linear and contrapuntal style, as well as dissonance treatment in Palestrina, in his well-known book. But since that time no one has attempted to match his labors in the detailed examination of the extant works of any other pre-tonal composer--yet there is no reason why a computer could not produce a parallel investigation of any works submitted to it, in a tiny fraction of the time and in a more flexible, more exhaustive, and more reliable manner.

In the area of harmonic, or rather intervallic, organization, the situation is much the same. To the extent that we can meaningfully separate the harmonic from the contrapuntal dimension in this style, there are many questions we would willingly put and for which the computer can prove inestimably useful. For example, questions concerning the types of intervallic progressions associated with textures varying from two to five parts, and within chordal spans ranging from a tenth or twelfth to three octaves between outer voices; questions designed to compare large numbers of two-voice interval-successions with the traditional rules of discant; those concerning dissonance treatment, in all its ramifications; concerning the relative destiny of

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[2] "Das 'Sprunggesetz' des Palestrinastils bei betonten Viertelnoten," Bericht über den Musikwissenschaftlichen Kongress in Basel 1924 (Leipzig, 1925), pp. 211-219.

sonority in three and more voices, especially the frequency of complete triads; and those concerning the norms of harmonic succession within the loosely defined diatonic framework we roughly construe as "modal" without yet being able to define more precisely the types of progressions associated with the various modalities. To see how difficult of access these problems are, one has only to consult the brief chapters on modality in these Masses in Carl Dahlhaus's unpublished Göttingen dissertation of 1952, Studien zu den Messen Josquins Des Prez, or the first volumn of Helmut Osthoff's recent monograph on his career and works.

Finally, and still only by way of preliminary illustration, it seems reasonable to think that the computer--even, to begin with, as a locating and sorting device--might be of great value in the dark region of specified and unspecified accidentals; in shedding light on that aspect of the notation which strongly conditions our view of the "correct" or at least plausible interpretation of the material itself--and in helping us to determine what may constitute the boundaries of plausibility. Of particular value will be the opportunity of obtaining and classifying the many linear and harmonic configurations that we believe (or suspect) require the insertion of editorial accidentals, not merely as optional readings but in order to bring them into conformity with the norms of procedure we believe to be correct. And of equal interest are those accidentals that are not omitted from early sources but are included in some or all of them even though they might have been, or should have been, inferred by the performers of the period had they been following the rules of musica ficta that we deduce from contemporary theorists--especially those theorists, such as Tinctoris and Aron, whose writings are chronologically, regionally, and intellectually relevant to the music of Josquin.

For both types of situations one of our primary aims should be to gain a view of the principles, if any, that govern the composer's treatment of potentially problematic intervals (especially the tritone and diminished fifth) in linear, harmonic, and cross-related situations, and in the innumerable rhythmic configurations in which such intervals may appear. As a first step in this direction, Mr. Howe has written a program that has already produced some initial results: a program which locates, by movement, voice, and measure number, all the accidentals in the Smijers edition, both the so-called "original" ones and those inserted by Professor Smijers as

editorial additions.

Even though this map of accidentals is wholly preliminary to more detailed representations of this immense network of problems, it nevertheless permits some initial inferences that could hardly be made in any other way. For instance, one question of considerable interest concerns the relationship between the so-called "original" accidentals and those inserted by a modern editor; the reason for including the latter is not that they have equal weight with the contemporary accidentals but that they form a useful first step in locating those passages that have at least been regarded by one knowledgeable scholar as requiring editorial alteration. It is also useful to be able to separate out those works and movements that apparently require many editorial accidentals from those apparently requiring few or none, as a step towards determining to what extent the composer may have worked with linear and harmonic details in ways that would produce such results. From even this rough index we see that the differences within the Masses of the first two books are striking indeed: 1) First, the normal original accidental that is specified in the sources is the flat; there is only one sharp sign (functioning as a natural) in the entire first two books of Josquin's Masses; 2) Second, the ratio of original flats to editorial flats is, for the most part, on the order of 1:3, i.e., in the average Mass there were approximately three times as many situations in which the flat had been explicitly inserted in his sources. Further, the average number of original flats in each of the Masses lies between about 20 and 50.

But a small number of these Masses turn out to differ sharply on either side of these norms: in the Masses Malheur me bat and La Sol Fa Re Mi the ratio of suggested to original accidentals is practically 1:1, and the actual numbers are also very small 8:6 and 12:13. This suggests, on the face of it, that these works may differ considerably from their companions in having very few linear or harmonic problems for which accidentals would be needed (granted, for the moment, and in the absence of expanded discussion, reasonable assumptions as to the rules of application). At the other extreme is the Mass D'ung aultre amer: here there are only 5 original flats in the whole Mass (apart from the signature flat)--but Smijers, for whatever reasons, found it necessary to add 88 more; a ratio not of 1:3 but of 1:17 (and this, by the way, is the shortest of all the Josquin Masses).

As further study of this aspect of the music continues it is to be expected that these observations will not only be refined far beyond their present crude state, but that as they change, they must inevitably form a new picture of the larger framework, developed from new details. Yet I think it equally obvious that even this rough map, made by the computer in a few minutes, represents at least a minor step forward, and one that could have been made by human hand only at the cost of labor more painful than I would care to contemplate.

In closing, I shall omit the peroration that is customary at this point, and conclude instead with a tape-recording of a movement from one of the Masses that has been electronically generated through that same computer that is turning out information about its musical details (an interesting dual function for the computer as "performer" and "musicologist" in one). All the work that led to this tape was done by Mr. Hubert Howe of our Department; the process used is that known as the Music IV program developed at Bell Laboratories and now being further developed at Princeton by James Randall, Godfrey Winham, and the others I mentioned earlier. The portion included here is the Kyrie of the Missa Gaudeamus, the third Mass in the first volume as originally published by Petrucci in 1502.

MUSIC DOCUMENTATION OF THE FUTURE[1]

Barry S. Brook

Documentation as a general term has been defined as "the group of techniques necessary for the ordered presentation, organization and communication of recorded specialized knowledge, in order to give maximum accessibility and utility to the information contained."[2]

The documentation crisis in virtually all disciplines is well known. It will grow worse. Every one of you, I am sure, has seen it in his own work. It has been demonstrated that the number of scholarly periodicals doubles roughly every fifteen years and increases tenfold every fifty years. Derek de Solla Price has shown that "80 to 90 per cent of all scientists that have ever been alive are alive today." Furthermore, to quote Eric Boehm, "a given subject with a dozen qualified scholars today, may have hundreds and thousands in 50 years."[3] Unless something is done about it, keeping abreast of one's discipline, even one's little corner in the discipline, will become an increasingly frustrating and impossible occupation; search time and search fatigue with resultant inefficiency will multiply exponentially.

This challenge is being met head-on with the aid of the computer in many branches of science, in business, and in government. The humanities, with some exceptions to be mentioned later, seem to be sinking rather than swimming in their uncharted sea of documentation. It must be made very clear that automation offers

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[1] An emended version of this paper was read at the Congress of the International Association of Music Libraries in Dijon, July 3, 1965 and later published in *Fontes Artis Musicae*, XII/2-3 (May-Sept 1965) 112-122.

[2] James D. Mack and Robert S. Taylor, quoted in *Information Storage and Retrieval* by Joseph Becker and Robert M. Hayes (New York: John Wiley & Sons 1963) p. 44.

[3] Eric H. Boehm, "Dissemination of Knowledge in the Humanities and the Social Sciences." *American Council of Learned Societies Bulletin*, XIV/5 (May 1963) 4.

no immediate pie in the bibliographical sky. Every forward step in the field of information storage and retrieval has been hard fought and was extremely costly of time and funds.

However, there have been many impressive steps in a very few years. To mention just a few: the computerized *Index Medicus* of the National Library of Medicine aims at total bibliographical control of current medical literature and is bringing considerable order out of potential chaos in a field where international information exchange can affect the saving of lives. Another example from the field of medicine is the joint medical library project of Yale, Harvard, and Columbia Universities, a cooperative computer-oriented library information operation.

In the legal profession, bibliographical control of U.S. decisional law, both state and federal, is on its way. In New York State, for example, Law Research Service, Inc., a commercial firm, provides its lawyer clients with "legal research by computer." For a modest fee, it will search its computer-indexed and stored legal library in answer to specific questions. Within forty-eight hours the client is provided with complete xeroxed copies of all pertinent decisions that might serve as precedents in preparing his brief. In chemistry, biology, psychology, engineering, etc., hundreds of thousands of articles and monographs are abstracted annually and indexed in depth with the help of data processing equipment.

Current experimentation with optical scanners, super-microphotography, photo-composed print-out, and consoles with television-type screens communicating with central computer memories provide tantalizing--and realistic--promise of future developments. In this brave new computerized world, the scholar will be able to sit in front of a screen in his office or in his private study pushing buttons with one hand and holding a gin and tonic with the other. His special typewriter enables him to hold "conversations" with a computer many miles away. Note-taking is hardly necessary since any page passing before him on the screen can immediately be reproduced in paper form or be recalled at will later. We may even dare dream of that famous little black box in which the entire contents of the Library of Congress or of the Bibliothèque Nationale, or both, are stored in speedily recallable form.

Whatever the future may hold--and let us be wary of naive speculation--the

present already contains many valuable techniques that we must learn to utilize. This paper is primarily concerned with the following questions: What are the possibilities and limitations of the computer in documentation? What is the documentation situation in the humanities in general? What data processing techniques are applicable today in music research and documentation? What concrete steps can be taken in the future to control the "information explosion" in music?

The modern electronic digital computer is a machine, or rather a group of machines, built by human ingenuity to meet the inescapable demands of our time. It is a tool that can add, subtract, multiply, and divide; it can store information in the form of numbers, letters, or other symbols; it is a tool that can make logical comparisons; it can move data around within itself and thus manipulate, organize, and reorganize its stored information in a multitude of ways; it is a servant that is tireless, that is obedient to intelligent commands, and that performs at incredible speeds. A computer's minute of time is like an eternity; its operations are measured in microseconds; a microsecond equals one thousandth of a millisecond, which is one thousandth of a second. To put it another way, a microsecond is to a second as a second is to a week and a day. And in half a second the modern computer can execute around 100,000 instructions! A computer-driven satellite of recent vintage can pour out its results at a (relatively slow) speed of 1600 lines per minute; this means that at 40 lines per ordinary book page, 40 pages can be printed out in a minute and a 400-page volume in ten minutes.

However, no matter how blinding its speed, how complex its calculations, the computer remains a dumb machine, a creature of the human intelligence. It may not commit its own errors, but it requires the most precise set of man-made error-free instructions, called programs, in order to operate at all. Its data has to be prepared for it and fed into it with infinite care and with considerable time and labor by human action.

Opposition to the use of computers in the humanities is extensive. This is not the place to discuss questions of man's relationship to the machine. It may be said, however, that automatic rejection of the computer on "philosophical" grounds makes as much sense as did, not so long ago, similar rejection of the typewriter, the adding

machine or the telephone. There are many kinds of scholarly and bibliographical investigations that will always be better carried out "by hand" while others will profit immeasurably from electronic assistance. We concur with Lewis Lockwood's pithy remark, "Having a computer is no substitute for having an idea" and suggest a corollary, "Having an idea need not require having to perform tedious labor suitable for a machine."

One cannot speak of the "computer" and "documentation" in the same breath without recognizing the implied dangers. "Information" and "knowledge" are not the same thing. A genuine contribution to knowledge can be made with only a miniscule amount of information but a third-rate intelligence is not likely to produce anything significant with even an oceanful of computerized data. Yet there is no denying the existence of an "information explosion." It must be faced. Whatever the relationship of this explosion to knowledge, to population growth, to literacy, we see that researchers and libraries are being inundated by it. This situation demands new techniques for cataloguing, organizing, and searching both old and new information. Necessity has to some extent been the mother of professional concern and invention. The library world, especially in the United States, has long been studying the question--the literature on the subject is already enormous.[4]

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[4] Apart from the vast and important periodical and report literature, mention may be made of the following major books:

Barbara Evans Markuson, ed. *Libraries and Automation*: Proceedings of the Conference of Libraries and Automation held at Airlie Foundation, Warrentown, Virginia, May 26-30, 1963, under sponsorship of the Library of Congress, National Science Foundation, Council on Library Resources, Inc. (Washington, D.C.: Library of Congress, 1964).

Automation and the Library of Congress: A survey sponsored by the Council on Library Resources, Inc. Submitted by: Gilbert W. King, Chairman, Harold P. Edmundson, Merrill M. Flood, Manfred Kochen, Richard L. Libby, Don R. Swanson, and Alexander Wylly (Washington, D.C.: Library of Congress, 1963).

J.C.R. Licklider, *Libraries of the Future* (Cambridge: Massachusetts Institute of Technology Press, 1965).

Joseph Becker and Robert M. Hayes, *Information Storage and Retrieval: Tools, Elements, Theories* (New York: John Wiley & Sons, Inc., 1963).

Charles P. Bourne, *Methods of Information Handling* (New York: John Wiley & Sons, Inc., 1963).

In the humanities in general, computer-aided research is a rather recent development but it has been increasing at an extraordinary rate. To cite a few examples from literature: Analytical indexes and concordances have been prepared by computer for the Dead Sea scrolls, for the writings of St. Thomas Aquinas, and for the works of a number of English and Spanish poets. A recent monograph of Milton's influence on Shelley has been considerably aided by the computer's discovery of hundreds of word-group relationships that had previously gone unnoticed by human eye and ear.[5] In a much celebrated study, two statisticians, working with computer help were able to determine which of two possible authors, Madison or Hamilton, wrote the anonymous portions of the American Federalist Papers, authorship of which had long been in dispute.[6] In machine translation and linguistic analysis a great deal of computer-aided research has been in progress for over a dozen years; to cite a single project: in Gallarate, Italy, the *Centro per L'Automazione dell'Analisi Letteraria* has processed and is analyzing fifteen million words in seven languages and in three alphabets (Hebrew, Greek, and Latin).[7] The inter-disciplinary nature of computer-assisted research in these fields is emphasized by the establishment, last year, of the "Institute for Computer Research in the Humanities" at New York University.

In the field of music, a growing interest in automation on the part of musicologists and music librarians is evident from such developments as the establishment of a Committee on Automation in Music Bibliography by the American Music Library Association, the special Tagung of the Deutsches Musikgeschichtliches Archiv in Kassel organized by Harald Heckmann, the participation of a number of musicians in the series of IBM-organized university conferences (Rutgers, Yale, University of California at Los Angeles, Boston, Georgetown, etc.) with titles such as "The Digital

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[5] Joseph Raben, "A Computer-Aided Investigation of Literary Influence: Milton to Shelley," *Literary Data Processing Conference Proceedings*, IBM Corporation, 1964, 230-274.

[6] Frederick Mosteller and David Wallace, "Inference in an Authorship Problem," *Journal of the American Statistical Association*, LVIII (1963), 275-309.

[7] Roberto Busa S.J., "An Inventory of Fifteen Million Words," *Literary Data Processing Conference Proceedings*, IBM Corporation, 1964, 64-78.

Computer as a Servant of Research in the Humanities and Arts," the IAML Congress in Dijon this July, and forthcoming national meetings of the American Musicological Society and the Music Library Association all of which will feature sessions devoted to the computer.

In addition to projects described at this symposium by Messrs. Forte and Lockwood, a series of investigations in analysis and bibliography is being conducted at New York University under the guidance of George Logemann of the mathematics department. Jan LaRue, for example, is using the computer to assist in a stylistic analysis of the symphonies of Joseph Haydn, testing such elements as harmonic rhythm, phrase length, etc., and their correlation. In other centers, scholars have been working in the field of the computerized thematic index, Lawrence Bernstein, for example, on printed 16th-century chansons, Harry B. Lincoln on frottole, and this author on 18th-century symphonies concertantes. In some cases, these studies employ the "aperture card," a punch card with a "window" on the right side for a full frame of 35mm microfilm of the original source, the left side being reserved for normally keypunched identifying data.

Generally, in music as distinct from music literature, the documentation picture has been improving somewhat. In the area of early music, there is obviously only a finite quantity, and bibliographical control thereof will come eventually. However, RISM (International Repertory of Musical Sources) would profit enormously from the application of data-processing techniques. For the past several years the Kassel office of RISM, which is inventorying pre-1800 works alphabetically by composer, has been receiving tens of thousands of cards pouring in from all over the world. It will probably take five or six years before this new "Eitner" publishes its first volume. May I add, that I believe that this long-awaited bibliography is already outmoded--and before it reaches the letter "A"--because it omits a major essential of modern music indexing, the musical incipit. Obviously, as in the case of thematic catalogues, musical notation requires coding into machine-usable symbols, such as numbers and letters. Several workable codes or "input languages" have been developed for this purpose. The use of such codes for music makes possible, for example: thematic indexes, lexicographically classified in a multitude of ways (e.g., by composer,

by key, by instrumentation), the automatic transposition of all incipits to C major or C minor, the identification of anonymi, the discovery of works of double attribution, etc.

The overall situation in musicological documentation today is grim. One word accurately describes it: inundation. Florence Kretzschmar, editor of *Music Index*, used the word several times in a recent conversation. Some years ago she investigated the possibility of computer help but at that time found it impractical. Her excellent index is years behind. Even further behind is Wolfgang Schmieder's invaluable *Bibliographie des Musikschrifttums*.

In the natural sciences, giant strides have taken place in bibliography. Modern automatic indexing and information retrieval are changing the face of the art. These techniques can and must be applied to music. The computer makes possible, for example, subject indexing to a depth humans would not dream of attempting; why not fifteen or fifty subject headings for a book, rather than the often utterly inadequate two or three? Creative programming has invented new kinds of automatically-permuted indexes--machine inspired--all with such euphonious names as KWIC (Key Word In Context), KWOC (Key Word Out of Context), and WADEX (Word & Author inDEX).

An invaluable device of modern bibliography is the abstract. In the bibliographical control of current scholarly literature, there seems to be a Mannheim-type crescendo of abstracting activity, with and without an obbligato of computerized indexes. There are over 2000 abstracting organizations in the world today, at least 500 of them in the United States. No such organization exists in music--but more about that later. Abstracts are also employed in an effective system of getting the right documents to the right people; commercially this has been called Selective Dissemination of Information (SDI). The key to this system, developed by IBM, is the "user profile." Every user submits a list of his specific scholarly interests, his "user profile," which is computer-stored. Current literature in his discipline is abstracted and the abstracts are similarly stored. User profile and abstract key-words are then compared by the computer. When a "match" is discovered, the user is sent a post-card containing the automatically printed-out abstract, and an attached second post-card which he is asked to return after pushing out one of four partially punched-out boxes marked:

Of Interest, Document Requested.....
Of Interest, Document Not Wanted.....
Of Interest, Have Seen Before.....
Of No Interest.....

The returned post-card is automatically processed. If the document has been requested, it is sent to the user. The computer also tabulates all the post-card responses, thus interacting with its users to make the system more efficient.

When it comes to the preparation of concordances, there are few scholarly techniques which seem more appropriate for computer application. The number and excellence of computer-assisted literary concordances is already extremely impressive. Musical concordances, using basically similar programming procedures, must soon follow suit.

Brief mention should also be made of other techniques, already developed technologically, which may eventually be of help in music documentation.

Ultra-micro-photography, for example, can be combined with the aperture card to produce the following variation on the gin-and-tonic fantasy described above (p. 29): take an entire score or volume of text, several hundred pages in length; reproduce it photographically (greatly reduced) in a single aperture window; add identifying call numbers and cataloguing data by keypunching information onto the left side of the same card; the cards are then sorted and stored automatically; the user, seated before an "ultra-micro-reader," presses buttons to call for the visual display of the library's computer-prepared catalogues, also from aperture cards; he then asks for the desired "volume" by dialing its identifying call number; data processing equipment locates the aperture card in seconds, and transports or transmits it automatically to the "micro-reader"; the user never touches the aperture card; but he can xerographically reproduce any page he sees by pressing the "print" button.

It should be added that a thousand such cards--the equivalent of a thousand volumes--take about as much space as a shoe box! It is true that no "ultra-aperture-card" library is in existence at the present time. It is nonetheless also true that no step of this bibliographic Eldorado is technologically unfeasible today. A rather similar U.S.-government retrieval system called WALNUT, that combines photographic miniaturization with automatic document retrieval, has been in operation for several years.

A word about automatic scanning devices that are now capable of "reading" several different varieties of type fonts directly into the machine. These devices by-pass the slow, potentially error-producing, input process of keypunching of cards or typing of machine-readable paper tape. A "scanner" for musical notation is technologically completely possible (see p.151). At the present time, it appears that only the need for funds is holding back its construction. On the other hand, the automatic print-out of music is already a reality. At the University of Illinois, Lejaren A. Hiller has developed the computer-driven Musicwriter for this purpose. Music printing by Photon disc and cathode ray tube is also in the offing.

To conclude:

Bold proposals are in order and I should like to make a few. First, we need a working meeting of those who have developed input languages for musical notation. We are fortunate that information retrieval is interdisciplinary and therefore much work has already been done for us by others. In music we have the special and additional problem that we must deal with symbols of our own. That problem we will have to solve on our own. A working meeting to study various means of encoding musical notation for machine storage is planned for the 15th of May in connection with IBM and through the good offices of Mr. Stefan Bauer-Mengelberg. Those interested in participating are invited to write me. Secondly, I would like to suggest that no major bibliographical study be undertaken in music or music literature without serious thought being given to the possible help a computer may provide. There are many kinds of projects that cry for this type of processing. Finally, I propose that we investigate the possibility of establishing an abstract journal of significant musicological literature published throughout the world, a sort of RISM for music literature. The journal could be worked on cooperatively in many countries and by the various universities that do graduate work in musicology. Abstracts would be stored in a computer, indexed and published, and retrieved in various ways on demand. This third proposal will be formally offered for consideration at the Dijon meeting of the International Association of Music Libraries.

DISCUSSION

CHAIRMAN: Before opening the floor to questions, may I ask Edmund Bowles, specialist in medieval manuscripts, to put on his other hat and talk as a musicologically biased representative of the International Business Machines Corporation. After him, I would like to call on Professor Mendel of Princeton to say a word.

EDMUND BOWLES: The first problem that we face, those of us in scholarship who are interested in using the computer, is to break down the wall of suspicion, fear, and ignorance maintained by many humanists towards the computer. One scholar said not too long ago that if you have to use the computer to answer a question, "it is not a question which I would care to put." Another gentleman, when sent an article on the use of data-processing in a historical study, returned it promptly with a note: "I do not understand this, but I am quite sure that if I did it would be of no value." My job with IBM involves visiting universities all over the country on the matter of computer-oriented scholarship in the humanities. I am often disturbed by the resistance to the use of this important new tool. I have met graduate students eager to use the computer on a legitimate project who have been discouraged from doing so by their professors who know nothing about the machine.

Secondly: Present facilities at the university computer centers are oriented quite understandably toward the engineer, mathematician, and physicist; they are inadequate for the humanist. Most of the programming courses presuppose a technical background or at least a basic understanding of mathematics. I have a musicological friend who was put to the task of programming quadratic equations when he, like myself, had forgotten what a quadratic equation is. This is no way to teach the humanist --the musicologist, the archeologist, or the classicist--how the computer can be of use to him. What we need are computer courses specifically for the humanist, run at least in part by the computer-oriented humanistic scholar himself for his peers. Only when those in the liberal disciplines pressure their computer centers will this come to pass. I think the task rests with you to persuade scientifically-oriented cen-

ters throughout the country to offer the kind of courses that are meaningful and productive to humanists.

A third problem: We vitally need an organization or at the very least a journal devoted to computer-oriented research in the humanities. There exists no clearinghouse, no center of information, no means of intercommunication between scholars in the humanities using the tools of data processing. Currently existing journals and learned societies are reluctant to assume this additional burden, especially outside their own discipline. We need more scholarly convocations such as this one. We need to avoid needless duplication of effort. We need fellowships and other means of support for humanistic scholarship involving the computer. Whether or not government aid will be forthcoming of course remains to be seen. But foundations ought to be attracted to this tool of tremendous potential. I know of only one foundation grant in this area and it's too early to say whether this will become a pattern or not. I would hope so. We at IBM are trying to breach the gap and have established a number of programs for computer-oriented research.

Fourthly: Following the lead of the social sciences, musicologists must establish data repositories on computer tapes. For a number of years both social scientists and historians have been patiently transferring census information and election statistics onto punched cards. The techniques are simple, although the work is time-consuming, and the results are of great significance. Musicologists could profit by efforts such as the Inter-University Consortium for Political Research at Ann Arbor to provide ultimately a world-wide source center for information, musical and bibliographical alike.

Finally, let me say that the computer seems to be here to stay. It is high time for musicologists to come to terms with it and accept it for what it is: a useful tool of tremendous potential.

ARTHUR MENDEL: May I say a word on the question of bold proposals. There is one proposal that has been made on many sides--I am familiar with it particularly from Michael Kassler--that is the need for an optical reader for music. We need a way of getting music read automatically for machine use rather than first translated into an input language, so that this terribly long, laborious, and inaccurate process of keypunching cards is avoided. It seems to be perfectly within the possibilities of

today's techniques. It needs a lot of money, more money than any one institution might be able to put up, but it would not be beyond the possibilities of many institutions working together. Such an optical reader would read the whole piece (you could always retrieve the incipits if that's what you wanted). You could have an entire repertoire stored in the memory of the machine.

A word too on why I think there is resistance to the idea of use of the computer in the humanities. I think we--some of us--share part of the blame and some of us invite part of it. I think we are inclined, in our enthusiasm for the computer's possibilities, to overestimate the importance of those characteristics of music and musical styles that can be quantified--only those can be dealt with by the computer--and to underestimate those that cannot be. When I gave a course in 16th-century music, I made a list for my students in parallel columns of characteristics which in the period roughly around 1500--let's say 1470 to 1530--could be considered relatively early in that period or, if they appeared late in that period, old-fashioned; and, characteristics which appeared mostly late in that period or, if they appeared early, could be considered very advanced. And I recently looked over that list to see how many of them could be quantified for computer purposes , and I was struck with the number of those that I considered of great importance of objective reality which could not, in any simple way at least, and some of them not at all, be codified. So I don't think anybody ought to get the idea that most of us believe that the problems of musicology are about to yield to the computer. I think some of them are. Let me give you an example: As some of you know, I have, for many years, been working on the St. John Passion. I have (roughly) some 10,000 cards of variant readings in the sources of the St. John Passion. At present my only way of manipulating these is by hand. It is too late and too time-consuming, I am told by my young graduate-student friends, to convert this into computer notation because the initial work has been done already. Now there is nothing to do but plow through the data manually. I have them on cards, obviously, so that I can rearrange them in different orders, one of my purposes being to establish the relationships between sources. These are very simple, logical relationships which could be perfectly well manipulated according to rules which a computer could handle. If I were starting that job again, I could undoubtedly save myself an enormous amount

of time by having at least some of the cards keypunched.

Another problem in this field, it seems to me, is that almost everybody who works in it--with some exceptions--is naive on one side or on the other. Some of us musicologists are terribly naive where mathematics and computer logic are concerned. The people who handle mathematics and computer logic easily are at times--we think--frighteningly naive where music is concerned. The result is that of the investigations so far accomplished, many of them turn out to be ridiculous from one point of view or the other. Either the musician has made inferences from the statistics that anybody who knows the first thing about statistics would think are not warranted, or else the statistician has used such data as to vitiate completely his no-doubt-very-soundly-arrived-at statistical conclusions. I have an example of this which I'd like to describe briefly; it was sent to me in the mail the other day. It is an article from the *Journal of Communication* for December 1964 called "Identifying the Unknown Communicator in Painting, Literature and Music." I'd like to ask whether, if you had the idea with which this man works, you could come to the conclusions that he has come to, which I think are correct conclusions. Suppose you were given only the first six pitches--no durations, no other characteristics--of considerable numbers of melodic excerpts, each sample being drawn from the works of seven different composers, and you were told who the seven composers were but not to whom each sample belonged. Could you assign by any technique known to you the samples to the proper composers? This gentleman succeeded in doing so. Using this very minimum information, he did so by statistical methods that ruled out the possibility of any other composer being the author of the sample by odds of more than 1000 to 1, sometimes several thousand to one. And when I tell you what the information was like, this is even more astounding. The information consisted of what are called themes in the Barlow & Morgenstern *Dictionary of Musical Themes* --any little catchy passage from a piece, sometimes beginning on the second note of the theme according to the way I read the theme, or beginning on the note before the theme according to the way I read the theme. All these are reduced in the back of this very handy book for librarians to a letter system and transposed to the key of C major and minor. For example, the theme, the first theme of Beethoven's C major symphony you will be happy to know is EFBCF♯F♯...

Working with data like this, he nevertheless succeeded in identifying with enormous probability the author of each of his samples. The samples consisted of 160 excerpts from each of the seven composers. If we had 160 samples of Beethoven, we probably would recognize that they were by Beethoven. I'm not sure that if we had 160 examples of just the letter names reduced to the key of C of the first six notes of Beethoven, we would recognize it as Beethoven or know that it wasn't Bach or Brahms. Or any one of a number of other composers. We are interested mostly in identifying a single piece...lots of notes from one piece, not a few notes from lots of pieces. And this investigation doesn't give you any clue to that. Any one piece may fall completely outside the norms established by these samples. It's not a realistic investigation from that point of view at all. However, it must tell us something about a constituent of style if you can tell the composers apart. It tells Haydn and Mozart apart with chances of more than 1000 to 1. It therefore must tell us something we didn't know. If I tell you further that in order to do this, the author separated the tones into five classes: tonic, 3rd degree, 5th degree, all other diatonic notes of the scale, and all chromatic notes of the scale--and the tone a 6th above the tonic, a minor 6th above the tonic, and the tone a minor 3rd above the tonic were in every case called chromatic tones. The nomenclature is all wet, you see; nevertheless he came to these conclusions. This is a remarkable example of the naiveté that afflicts these investigations and at the same time, of their remarkable possibilities.

CHAIRMAN: The floor is now open for questions.

ERIC WERNER: How is it possible, or is it possible at all, to synchronize information on all parameters and feed it into the machine in compact form?

GEORGE W. LOGEMANN: It cannot be done compactly. But there are ways of combining all the information if you are willing to take the time and space. We can store millions of information characters to describe the music, and then proceed to correlate information on factors such as rhythm and harmony.

WILLIAM KIMMEL: Does the computer have an ear? That is, can it analyze what is played to it? Has any progress been made in computer analysis of harmonic and rhythmic content?

LOGEMANN: Yes, in the sense that people at Bell Laboratories are able to decompose speech tones, frequency analyzers can break down musical signals into their

components.

KIMMEL: Can the computer identify, say, an augmented sixth chord?

LOGEMANN: It is possible, provided that the programmer writes an explicit set of rules on how to identify an augmented sixth chord.

ERIC VAN TASSEL: The basic problem seems to be this: Can the computer be so hooked up with electronic sound equipment that the performance of the piece will provide the input? Can you program something to go from physical sound to punched cards, paper tape, magnetic tape, and whatever you want? If this is the case, then obviously the analysis of augmented chords is merely another step which can or cannot be taken. The primary question is, can we get aural input at all? If so, what is its efficiency quotient as an input method?

CHAIRMAN: You can get aural input in single, double, and triple-line counterpoint, but if you have a full orchestra it would be rather complicated.

STEFAN BAUER-MENGELBERG: Although aural input is feasible, it does give rise to the problem of information loss. Pitch, for example, would be indicated by its distance in semi-tones from a given note. Thus, F-sharp above middle C could be represented by the integer 6, since it is six semi-tones higher. But G-flat would be represented the same way--and this constitutes loss of information. Take, for example, the controversy raised by a question on accidentals in the Beethoven Op. 106 piano sonata: Just before the recapitulation in the first movement, there is a section with a number of A-sharps and F-naturals--unusual for an E-flat major piece. It is attributed by some to Beethoven's sloppiness in indicating accidentals, but accepted by others at face value. Had Beethoven written B-flat and F-natural, there would have been no controversy. As you can see, what is in the printed score is of considerable importance, and this is lost in aural input.

AUSTIN CLARKSON: Would there be a substantial difference in the encoding of music from one period to another? For instance, composers today are extremely concerned with delineating envelope and spectrum for attack and decay characteristics. Now, can't such concerns require an expanded input vocabulary?

BAUER-MENGELBERG: There are, of course, systems of notation today that fall completely outside the range of anything that we regard as conventional. I don't know if languages have been developed that will encode such music with any degree of precision. I know that the language developed by Regener is open-ended in the sense

that new symbols can be added almost *ad infinitum* to account for the peculiarities of usage by the composer. But it seems to me that all the devices available for what can reasonably be called standard notation, plus equally large sets of auxiliary symbols can be handled by several of the languages.

DIKA NEWLIN: I have a question for Mr. Forte: Have your practical applications of the computer to Schoenberg analysis reached row analysis of twelve-tone works? Do you plan to undertake row analysis?

ALLEN FORTE: No. The project has been limited to non-serial atonal music.

NEWLIN: Is there a special reason for not applying computer techniques to twelve-tone music?

FORTE: Yes. I feel that twelve-tone music is sufficiently understood at this point to allow generalization about it. Milton Babbitt's work in particular provided a useful framework. Non-serial atonal music, however, still remains enigmatic, as far as I know. From the standpoint of research it is a more interesting problem.

NATHAN BRODER: Mr. Mendel, how much time did you lose by starting when you did on the St. John Passion? If you had had a computer available and a language in which to program the various problems, wouldn't it have taken just as long, perhaps longer, to get the problems programmed as it took you to make out your cards? And wouldn't they have had to be proofread?

MENDEL: My cards required proofreading as well. Now with regard to your other questions: It may well be that for one work the amount of programming would be incommensurate with the gain, or that you might not have any gain. But where there are many works, the same kind of programming could be used for all if a system were devised. Moreover, one could then investigate certain aspects that these works may have in common, which one could not otherwise do at all, or do as easily.

CHAIRMAN: Another word might be added in answer to Mr. Broder's question. Once the material is keypunched, the proofreading can be aided by the computer. Furthermore, the data can be manipulated in a multitude of ways without running the risk of any further errors, and this--certainly in bibliography, thematic indexing, and the like--can be of tremendous value.

MENDEL: Of course the optical reader would eliminate all the errors, provided

that the original material fed to the optical reader is correct. It wouldn't eliminate kinds of errors found by computer programs in the Smijers Edition, but it would eliminate those that the keypunchers have added in the course of transcribing.

EGON KENTON: Mr. Lockwood indicated that in certain Masses of Josquin, Albert Smijers inserted 70 per cent more B-flats than were originally put in by Josquin. This information retrieved by computer corroborates the belief I have had for some time, that Smijers did not apply the rules of solmization to the single parts; otherwise he would not have inserted so many accidentals. Since such conclusions may be reached without the aid of a computer, I wonder whether the time, money, and effort spent on finding them out with a computer are worth it. In the light of this, I would like to ask Professor Mendel to suggest what type of research is feasible and rewarding computer work.

MENDEL: I think that the best way to approach this problem is to push along a little in different directions, using the computer for what we cannot readily count by hand. Undoubtedly some of the things we look for will turn out to be very much more valuable than we had anticipated, and others will provide a mass of data that we cannot apply to a particular investigation. As far as the value of a project such as the computer investigation of Josquin Masses is concerned, perhaps Mr. Lockwood would explain what he plans to do with the investigation of solmization rules and musica ficta.

LEWIS LOCKWOOD: In our very preliminary stage of investigation, all that was attempted was to answer the following question, an apparently simple one, but actually rather difficult: On what basis would you add accidentals? It is interesting to try to discover to what degree we can derive some rational principles for using them. One way of doing this is to determine the amount of alteration that each piece requires. What we further need is a balanced picture of the relationship between a plausible set of rules and a body of apparently implausible harmonic-melodic configurations that those rules should govern. We must make the music appear correct to some degree, with regard to what is considered correct for the period. Before counterpoint rules are applied to a body of music, they must be carefully sorted out for their intellectual and chronological appropriateness. The same approach applies to our study of musica

ficta in the Josquin Masses. In that regard, I want to make it clear for whatever record there may be that I don't mean--in anything I have said today--to denigrate the Smijers Edition. We all owe an immense debt of gratitude to Father Smijers for having conceived and carried out this edition as long and as far as he did. Without it no project such as ours could ever be initiated. It implies a certain set of values which we should all attempt to carry forward.

SYMPOSIUM II

MUSICOLOGY AND THE COMPUTER II

Input Languages to Represent Music

Conference co-sponsored by the Automation Committee of the Music Library Association, May 10, 1965, I.B.M. Systems Research Institute, New York

THE FORD-COLUMBIA INPUT LANGUAGE

Stefan Bauer-Mengelberg*

*(*The following is a summary of Mr. Bauer-Mengelberg's discussion of the code; it has been extracted from a transcription of tapes made at the session and includes a list of symbols distributed at the time.)*

The objective of the Ford-Columbia project, directed jointly by Dr. Melvin Ferentz and myself, is to develop a code system that will enable us to print music under computer control by using currently available photo-composition equipment. We are interested primarily in encoding complete works, not merely incipits, or a tone, or harmony. Our aim is to produce a code language that represents more of the graphic element of a piece of music than do other languages that have been proposed; we are not interested in typewriter representation.[1] The photo-composition device we will use is called the photon. It has a character font of 1,440 symbols which are embedded in a glass disk that rotates at high speed; the symbols, selected by computer, are projected through a complicated optical system onto the proper place on the film which is then used for printing.

Space Codes:

To produce a computer-controlled layout by means of the above-mentioned process, we proceed by means of two types of codes, the one for vertical measure, the

---

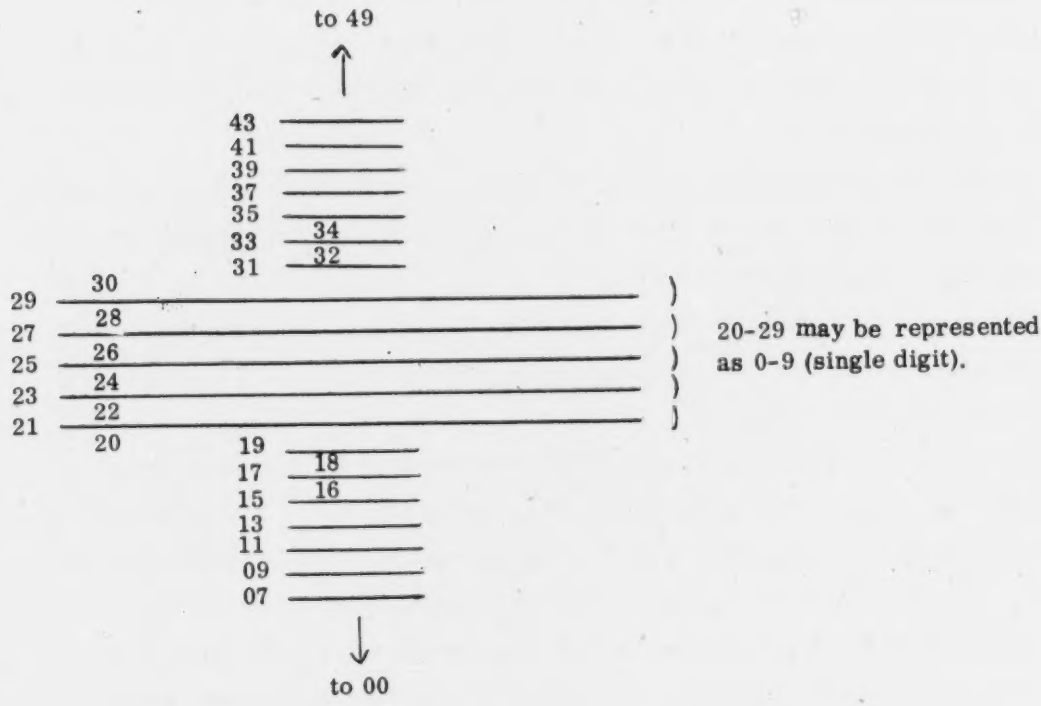
[1] We use the character set of the IBM Type 29 keypunch:

26 Letters
10 Numeric Digits
28 Special Characters:

12 General Punctuation:	( ) ' " _ , ; . : ? ! Blank
9 Mathematical:	+ - * / | ¬ < > =
6 Commercial:	# & % @ ¢ $
1 Unassigned:	0-2-8 Punch

other for horizontal measure. The vertical code--a space code--measures position relative to the staff according to the following system. The lines are numbered 21, 23, 25, 27, 29 and the spaces, 22, 24, 26, 28 and so on. This measure continues for ten ledger lines both above and below the staff. Normalizing the staff at roughly 25 allows obvious advantages for transposition up or down. But since the bulk of music is written on the staff, we also permit ourselves some liberty and can simply drop the 2's. In other words, we have a 2 suppression mode which allows us to encode what is actually on the staff by a single-digit representation.

Space Codes



In horizontal measure, the only feature of concern is vertical simultaneity or horizontal displacement; the amount is irrelevant. We indicate horizontal displacements by spacing as one would on an ordinary typewriter to begin a new word. The amount of space is determined later by the computer.

This description applies to one-staff notation. Where there is two-staff notation, the second staff is referenced by simply adding 50 to each of its codes. This procedure applies to parts for a single instrument; a score for multiple instruments would be composed differently.

Initial Information:

In encoding complete works, much time could be saved by abstracting certain types of information at the very beginning, e.g., which instruments are playing and what their transpositions are. Codes for the individual instruments will begin with the letter "I". Each instrument is assigned a two-digit code, e.g., I/01, I/02, I/03, etc. The system allows for 99 instruments plus the marginal space for general encoding. Where numerous metrical changes occur throughout the score, the metrical scheme could be typed out at the outset and later inserted by computer into each of the instrumental parts.

Further initial information will include clefs, time signatures, and key signatures.

Clefs: Shown by space-code line number, exclamation point (attention), and letter of the clef, e.g., 25!C=alto clef.

Time Signatures: Indicated by exclamation point, M (meter), and metrical symbol (fractional signatures, e.g., $\frac{6}{8}$, use a separator (6:8) so that $\frac{6}{8}$ does not become 68), as follows: !MC=C !M3:4= $\frac{3}{4}$

Key Signatures: They can be either standard or orthodox. For the standard key signature, we indicate first the number of accidentals and then the symbol for the accidental being used (sharp= # , flat= -), all preceded by an exclamation point and K (key): !K3 =A major key signature. For an unconventional signature, e.g., B-flat and F-sharp, we indicate that a flat occurs on line 25 (or 5) and a sharp occurs on line 29 (or 9); in such signatures, the symbol for the accidental occurs first: !K-29#25

Notes:

As to the notes themselves, the system of space-code identification allows us to place any symbol vertically. This applies to dynamic markings as well. We have

also developed a duration code which is mnemonic except for Z. For dotted notes, a dot is added to the letter: H. = a dotted half note.

Duration Codes

B	Brevis
W	Whole
H	Half
Q	Quarter
E	Eighth
S	Sixteenth
T	Thirty-second
X	siXty-fourth
Y	one hundred and twentY-second
Z	two hundred and fifty-sixth

Besides pitch and rhythm, there are numerous other features that must be considered: *Stems:* In many instances, it is important to know whether a note is up-stemmed or down-stemmed. If, for example, two oboe parts are on the same staff and the parts cross, there must be a way of keeping the parts distinct. The symbols for stemming are U and D for up-stem and down-stem; if a note has two stems, we use a % sign. *Slurs and Ties:* We must know precisely where each slur (or tie) begins and ends. First there is the general code which indicates where the slur begins. Then the slurs are identified digitally; this allows us an infinite number of slurs, although we hope never to encounter more than ten simultaneously. In addition, we can show whether the slur arches upward or downward; this serves as a separator between the digits as well. For ties, we use "J" after the duration code: 25WJ 23QJ =
Beaming: We give explicit instructions for beam structure by means of parenthesization, opening the parentheses for each beam that begins and closing them for each beam that ends. This method is what we call the short form for beaming. We also have an alternate method in which a digit is attached to the up- and down-stemmed notes, the value of the digit signifying the number of beams.

Dynamics: !V (V=volume) followed by the dynamic marking (no space), e.g.,

!VPP=pp

Accidentals: Sharp sign is indicated by # and double sharp by ##
Flat sign is indicated by - (dash) and double flat by -- (2 dashes)
Natural sign is indicated by * (asterisk or star)

Other symbols: staccato = ' (single quote)
tenuto = _ (underscore)
staccatissimo = " (double quote)
marcato = ("greater than" sign)
fermata = ; (semicolon)

Repetition: To avoid repetition of encoding, we have developed methods of recall. For repeated passages, we have a code that uses the equal sign. Another method is a MACRO-defining capacity which does pretty much the same thing--not for an exact string of characters but, say, for a chord. Where, for example, chords move in parallel motion, you can define the initial chord and also define a variable. Then rather than to spell out the whole chord each time it appears, you give the MACRO dictionary number and change the variable appropriately.

EXAMPLE: Beethoven, 5th Symphony, 3rd movement, cello.

!F!K3-!M3:4 1Q / 4 6 8 / 31H 33Q / 32H 7#Q / 8H.J / 8H. /

THE PLAINE AND EASIE CODE

Barry S. Brook

The *Plaine and Easie Code* is a system of notating music using ordinary typewriter (or keypunch) characters.[1] The code is easy to learn, speedy to use, and requires a minimum of symbols. It is completely accurate as to pitch and rhythm and, as shown in the following paper by Messrs. Gould and Logemann, it can be expanded to include other variables such as dynamics, phrasing, harmony, stemming, etc., in sum, the complete musical score.[2] By computer programming it is possible to transpose the coded music automatically,[3] search for duplications and variants, check accuracy of number of beats within a measure, etc. Feasible also with properly coded data are sophisticated musical analyses, automatic printing of both score and separate parts with a single encoding, and even electronic performance of the music. However, despite its machine readability and data-processing potential, the code is designed to be easily used by human beings. Fundamental to the system is its close mnemonic relationship to conventional musical notation. Its error potential is low and it can be used by musicians, librarians, and scholars in the field, in a variety

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[1] A complete description of the code may be found in Barry S. Brook, "The Simplified 'Plaine and Easie Code System' for notating music: a proposal for international adoption," *Fontes Artis Musicae*, XII/2-3 (1965) 156-160. The Simplified Code, as currently employed, was perfected in 1965 following considerable experimentation and after discussion in meetings of the International Association of Music Libraries. It supercedes the earlier version described in: Barry S. Brook and Murray Gould, "Notating music with ordinary typewriter characters: (A Plaine and Easie Code System for Musicke)," *Fontes*, XI/3 (1964) 142-155. Published with this article were valuable commentaries by Jan LaRue, Ingmar Bengtsson, Nanie Bridgman, Rita Benton, and Paule Chaillon-Guiomar (pp. 155-159).

[2] See Murray Gould and George W. Logemann, "Alma: alphameric language for musical analysis."

[3] See Gary Berlind and George W. Logemann, *An algorithm for musical transposition* [MS, duplicated] (New York: New York University Institute for Computer Research in the Humanities, 1967).

of ways, and without reference to the computer. Coded materials can be readily filed, alphabetized, and compared, by eye. With very little practice, one can learn to read and write the code, indeed to sing from it. The code can be applied to all Western music from Gregorian Chant[4] to dodecaphony.

The *Plaine and Easie Code* is ideally suited for thematic cataloguing. It requires only a single line of symbols (recorded by hand, typewriter or keypunch); there is no need for backspacing or a second pass over the line. One of the most pressing needs in music bibliography today is the need for an internationally accepted code for the notation of musical incipits. No matter how complete and precise the cataloguing, positive identification of a large percentage of musical sources is not possible without musical incipits (ten or twelve notes suffice); and since conventional notation is time-consuming to write down, costly to print, and unsuitable for electronic data processing, these incipits are best given in coded form.

EXAMPLE: Beethoven, 5th Symphony, 3rd movement, cello.

,,,4G / ,C E G / '2C 4E / 2D ,4#F/ 2.G _/ C /

(Allegro, bBEAminor, 3/4)

The *Plaine and Easie Code* is given in two parts after identification (where appropriate) of composer, title, instrumentation for the work as a whole, movement, instrument or voice used in the incipit, and clef. (Clef is indicated only when it is not the G clef on the second line, and then by the following system: F-4 F clef on the fourth line; C-3 clef C clef on the third line; G-2/8 G clef for tenor voice. Similarly the instrument or voice is assumed to be the top treble line unless otherwise indicated.

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[4] See Murray Gould, "A keypunchable notation for the Liber Usualis," in Harald Heckmann, ed., *Elektronische Datenverarbeitung in der Musikwissenschaft* (Regensburg: Gustav Bosse Verlag, 1967) pp

Part I (Initial data)

Tempo, key signature, and meter are given first and in parentheses. Abbreviations are avoided in the interest of clarity. When either tempo, key signature, or meter is absent, this is indicated by a triple blank space, separated by commas, for example: (Adagio, ,4/4), indicating that there are no sharps or flats in the signature.

Tempo: Written out fully; metronome marking, if present, is added immediately afterward. MM 2 - 120 (half note equals 120) or MM 16 - 240 (sixteenth note equals 240).

Key signature: Sharp or flat (♯ or b) followed by the letter names of the sharps or flats as they appear, e.g., ♯FCG. If the work is obviously in the relative minor, a lower case "m"--or the word "minor"--is added. The name of the tonality need not be mentioned except when the signature is "incorrect," as is the case occasionally in Baroque music; this may be indicated by adding a question mark and the name of the actual tonality:

bBEm?C would mean C minor despite only two flats
bBEA?Ab would mean Ab major despite only three flats.

Meter: Given exactly as indicated in the music, without abbreviations, for example: 3/4, 2/2, 2, C, ₵, 3, O, etc.

A change in tempo, key signature, or meter in the course of the incipit will be indicated with double parentheses, e.g., ((3/4)) shows a change from the original meter to 3/4.

Part II (The Notes)

This part deals with the notes themselves, indicating pitches by capital letters, rests by a dash, duration of both notes and rests by number.

Duration: Given in numbers, 1 2 3 4 5 6 7 8 9 0, for both notes and rests. The numbers precede pitch letters and *remain in effect*, crossing bar lines, *until a different duration number appears*.

1	whole note or rest	3	32nd
2	half note or rest	5	64th
4	quarter, ditto	7	128th
8	eighth	9	Breve
6	16th	0	Longa

Dotted notes indicated by period following the duration number: 2.C = dotted half note C

Rests indicated by a hyphen: 4C-2- =

Ties by underline or plus sign : 2C_4C [or 2C 4C] =

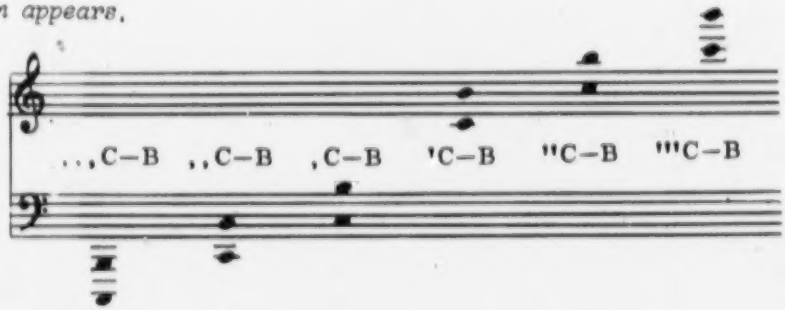
Triplets and other unusual rhythmic groupings are enclosed in parentheses preceded by total duration number: 4(8 CDE)

Fermata indicated by parentheses around a single pitch or rest: (C)

Pitch: Given in letters: A B C D E F G.

Accidentals immediately precede pitch letters as in conventional notation: Sharp ♯ [or X] . Flat b [or Y] . Natural n [or N] . Double sharp x [or XX] . Double flat bb [or YY] .[5]

Register (Octave Placement) indicated by commas or apostrophes placed in front of duration and pitch symbols and *remaining in effect until a different register sign appears.*



Additional Symbols:

/ Bar line // Double bar line
t [T] Trill
g [Q] Grace note; also used for cue sized notes
/-/ Full measure rest /-3/ Three measure rest
/:/ [or /R/] Repeat preceding measure /:2/ [or /R2/] Repeat 2 measures preceding

8.68 ABC DEF GAB Repeat rhythmic pattern (i.e., 2 or more successive duration numbers) for each succeeding group of pitches: etc.

[5] N.B.: Symbols given are those available on an ordinary typewriter or an 029 keypunch with lower case letters. Alternate symbols for the 026 keypunch using only capital letters are given in brackets.

ALMA:
ALPHAMERIC LANGUAGE FOR MUSIC ANALYSIS[1]

Murray J. Gould and George W. Logemann

INTRODUCTION

Alphameric Language for Music Analysis--ALMA--is a notation system for transcribing printed music in terms of letters, numerals, and other symbols. Whereas conventional notation (i. e., staff notation) comprises aggregations of a highly stylized set of symbols embedded in a two-dimensional field, the music language to be introduced employs symbols chosen only from those available on the IBM 029 Keypunch, strung out left to right. The 029 character set is

ABCDEFGHIJKLMNOPQRSTUVWXYZ

1 2 3 4 5 6 7 8 9 0 + - , ' / ( ) * $. = : ; ! @ % ¬ > < _ # " ? &

The authors' purpose in providing this language is to facilitate the keypunching of music data to be analyzed in a computer-oriented information retrieval system.

By music data is meant

1. Music written in staff notation.
2. Facts about the music, such as composer's name, source of data, etc.
3. Facts such as particular performance practices, or results from previous analysis.
4. Researcher's interpretations of ambiguities, and sets of alternative interpretations of any aspect.
5. Researcher's comments.

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[1] ALMA has evolved from the Plaine and Easie Code invented by Barry S. Brook and Murray J. Gould. The authors are indebted to Professor Brook for motivating the present project and continuing to support its development with discussions and suggestions. The authors are also indebted to the Institute for Computer Research in the Humanities at New York University for providing research time and facilities.

6. Music written in other than staff notation.
7. Music for which a language does not yet exist (both folk and electronic).

The immediate scope of this paper is the transcription of staff notation; 6 and 7 are ultimate goals of the language, and will not be treated here, although the authors hope that the feasability of such a goal will make itself apparent to the reader.

It has been intended to make the language both flexible and concise.

In particular,

1. Most repetitive patterns may be abbreviated.
2. The researcher can decide how much information to transcribe during the scanning of a passage in staff notation. For example, he may transcribe only pitches and durations, leaving for a second scan the transcription of texture and dynamic markings, or, alternatively, he may transcribe all of these in a single scan.
3. The researcher chooses the order of transcription.
4. There are alternative means available for transcribing particular patterns. E.g., there are three ways to notate chords.
5. Some of the language's symbols may be written in any order. All of the above features are designed to lessen the consequences of forgetting.
6. The ultimate choice of symbols to be used in the language is actually up to the researcher. The authors will suggest certain mnemonically convenient symbols, which operate well within the syntactical structure of the language.

Thus we have in mind that the researcher must describe his notational scheme to the computer in a meta-language, in terms of which he will ask questions concerning the data. He must describe explicitly various semantic conventions, in particular those conventions regarding information essential to the correct interpretation of the symbols. For example, the input program (hereafter, the assembler) of the retrieval system must interpret key or signature statements in order to translate pitch names correctly. (We leave to a future paper a description of the exact mechanism of the assembler, the metalanguage, and information retrieval system. For the present we assume that the assembler's metalanguage is sufficiently rich to admit an explicit description of each notational convention we shall suggest.)

Thus we propose—

1) A language which we consider adequate for transcribing all music written in conventional notation.
2) A technique by which the language can be augmented to include special notations found in one or another particular pieces of music.
3) A generalized syntax-directed computer program system that will easily adapt to particular variations.

* * * * *

The paper has the following outline:

1. Overall Organization
    - 1.1 Scan
    - 1.2 Basic units
        - 1.2.1 Notes
        - 1.2.2 Attributes
    - 1.3 Beginning times
        - 1.3.1 Scan order
        - 1.3.2 Multiple scans
    - 1.4 Bar lines
2. Notes
    - 2.1 Note names
        - 2.1.1 Single notes
        - 2.1.2 Chords
        - 2.1.3 Rests
        - 2.1.4 Repeated note names
    - 2.2 Durations
        - 2.2.1 Single durations
        - 2.2.2 Compound durations
        - 2.2.3 Cyclic duration definition
    - 2.3 Expanded phrase
    - 2.4 Groupettes
        - 2.4.1 Explicit groupettes
        - 2.4.2 Groupette durations
    - 2.5 Tied notes

3. Attributes

3.1 Attribute definitions
3.1.1 Simultaneous attributes
3.1.2 Cyclic attribute definition
3.1.3 Scope to the left
3.1.4 Locating scopes
3.1.5 Compound scopes

3.2 Attribute modes of application
3.2.1 General mode
3.2.2 Specific mode

3.3 Attribute names
3.3.1 Suggested attribute classes
3.3.2 Suggested attribute names

3.4 Attributes outside delimiters
3.5 Algorithmic attributes
3.6 Conditional (or editorial) symbols

4. Controlling the transcription
4.1 Scan control
4.1.1 Scan relocation
4.1.2 Scan movement
4.2 Repetitions

APPENDIX

A. Extensions
A.1 Quarter tones
A.2 Percussion notes
A.3 Interval with fundamental
A.4 Fractional durations
A.5 Groupette attribute
A.6 Transliterate
A.7 Transpose

B. Alternatives
B.1 Relative pitch convention

1. *OVERALL ORGANIZATION OF THE TRANSCRIPTION*

1.1 Scan:

A page of music notation has two dimensions but will be transcribed into a one-dimensional string of symbols. Therefore the items on the page of music first must be ordered in some way, the order in which they will be transcribed. Then, while transcribing, one will examine each item in order and write down the ALMA code. The order of examining music notation is called the path of the scan: the item currently being examined is at the point of the scan, or more simply is the item being scanned.

1.2 Basic units:

In music notation, we assume that all items of interest fall into one of two categories: (1) notes, and (2) attributes. (An attribute is thus a fact or any item other than a note. The category notes includes chords and rests.) Thus, the transcription will be a one-dimension string of symbols, collected together into short groups representing notes. interspersed with other short groups for attributes.

N.B. In the following we present definitions for a formal language; hence we will use the same noun to refer to both an entity of printed notation and the symbols into which the entity is transcribed. Underlined symbols are those actually written in the transcription. For example, we refer to 2, 4, 8, etc., as "durations" in the sense of "symbols coding duration".

1.2.1: Notes: Notes (discussed in section 2) are the more fundamental of the two classes of basic units. Essentially, each note must have a note name and a duration. The note name may be a single note, a chord, or a rest. Notes may be collected into groupettes, in which the durations of the individual notes are modified so that the groupette takes a specified duration. Durations may be tied together.

To condense the transcription we have established a number of conventions for

abbreviating symbols for notes: many act in the same manner as accidentals--they are stated once and apply for a length of time given by convention. These conventions are stated in their respective sections; other techniques for repetition, etc., are presented in section 4.

1.2.2:Attributes: Attributes (discussed in section 3.) themselves fall into three categories: those which give specific musical information about the notes (e.g., a dynamic or texture marking), those which specify how other symbols are to be understood (e.g., a key signature or transposition which indicates that some pitches are implicitly modified), and those which control the scan; i.e., which indicate how one would recover the two-dimensional page display from the one-dimensional transcription string.

First, however, we must state how notes and attributes are combined into the transcription of a piece.

1.3 Beginning times:

A note or an attribute is a short "word" composed of alphameric symbols (letters, numerals, and other special symbols generally occurring on computer typewriter and keypunch keyboards).

The transcription process consists of scanning notes on the printed page, translating the notes into symbols, and writing them down in the same order. Appropriate symbols are described in sections 2 and 3.

The core of the transcription problem is the location of each event in time; i.e., the specification of the beginning time of each event. Since notes contain duration information, and since one note begins the instant following its predecessor, we use the notes themselves to set up a time table in terms of which attributes can be located.

1.3.1:Scan order: In order to correctly locate items relative to each other, we assume that the transcriber

(1) Scans from left to right

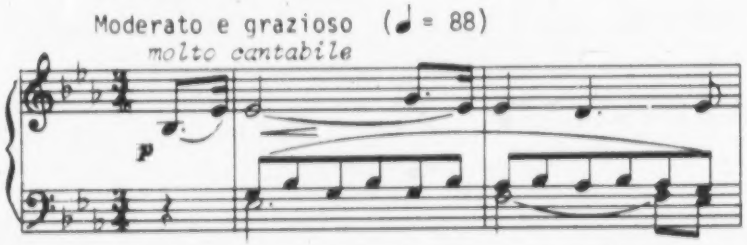
(2) Codes attributes before he codes notes.

That is: Those notes and/or chords and/or rests which are consecutive (each beginning immediately after the previous one ends), are scanned left-to-right. As each note, chord, or rest is scanned it is translated into a note. Each note is written, the string of notes proceeding left-to-right. (Consecutive notes, therefore, represent consecutive notes and/or chords and/or rests.) Bar lines are transcribed as they occur. Attributes are inserted directly before the notes to which they apply.

The point of the scan corresponds to the instant immediately following the last transcribed note, chord, or rest. When a note, chord, or rest is transcribed the point of the scan moves a distance to the right corresponding to the duration of the transcribed item. Attributes do not move the point of the scan. When the transcriber codes an attribute, we assume he is still scanning items beginning at the same time that the attribute just coded begins.

1.3.2:Multiple scans: Each scan through a passage is called a pass. Because transcribing all notes and attributes in one pass across the page may be inconvenient or impossible (using the symbols we prescribe), we allow the transcriber to indicate that the path of the scan doubles back to pick up items omitted on the first scan. (Scan control is discussed in section 4.1.)

For example: Beethoven, Sonata for Piano Opus 31 No. 3
Movement III
Minuetto



The notes and rest in the preceding passage may be coded as follows:

1) Upper voice is transcribed. Point of the scan is returned to the beginning.
2) Middle voice is transcribed. Point of the scan is returned to beginning of measure one.
3) Lower voice is transcribed.

The suggested sequence of scan relocations is felt to be the most convenient one for this passage. However, the coder has considerable choice.

1.4 Bar lines:

As one scans left to right across a bar line, one writes into the transcription a

/ (slash).

(Special bar lines--e.g.. repeat signs--are indicated by attributes.) This rule applies only when a note terminating immediately before the bar line and a note beginning immediately after the bar line are consecutive in the path of the scan, not counting attributes.

2. NOTES

Notes constitute groups of symbols for transcribing single notes, chords, and rests. A note has two parts: note-name and duration. Note-name is the general term referring to the pitch of a single note, the pitches in a chord, and the symbol indicating a rest: the next three sections describe symbols for note-names.

2.1 Note-names:

A note-name is either a pitch, a chord, or a rest.

2.1.1: Single Notes: The pitch of a single note is a single letter preceded, where necessary, by letters for accidentals and symbols indicating register.

The pitch name of a single note is one of the letters

A B C D E F G

A pitch name may be preceded by any meaningful combination of accidentals taken from the letters

X Y N

representing respectively # (sharp), ✱ (double sharp), ♭ (flat), and ♮ (natural). Possible combinations include YY (double flat), N# (change from flat to sharp), etc.

Familiar conventions apply here, namely that an accidental remains in effect up to the next bar line or until replaced by a different accidental applied to a note of the same pitch name, and that accidentals mentioned in the key signature (see section 3) are renewed after each bar line.

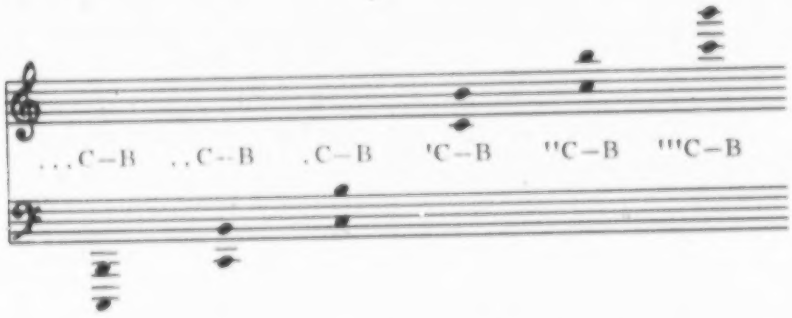
Single notes fall into octave regions, each containing the notes from a C to the next higher B. The register of a note indicates the octave region containing the note. In ALMA, register is stated using the symbols

' (apostrophe) and , (comma).

If a note falls in the octave extending upward from middle C, we transcribe its register ' (apostrophe). Successively higher registers are transcribed with additional ' 's (apostrophes).

Likewise, if a note falls in the octave below middle C, its register is transcribed , . Each successively lower register is indicated with an additional , .

Some of the possible registers are identified as follows:



Every pitch name is preceded by a symbol indicating its register. However, a particular register symbol may be omitted if it is identical to the last stated register symbol (i.e., if two or more successive pitch names fall within the same register). Thus a register symbol applies to the pitch name it precedes and to each following pitch name, until a new register is stated. (This is the first example of the abbreviation rules mentioned in Section 1.2.) We define the current register to be the register that applies to pitches for which no explicit register symbols have been stated.

In summary: a pitch is a register, accidentals and a pitch name, in that order. Correctly obeying convention, one may omit the register and/or accidentals.

Pitches with Registers

'D 'G "C 'E / ,A ,B 'B "B /

Omitting redundant registers

'D G "C 'E / ,A B 'B "B /

Accidentals

Redundant registers omitted

'C "YE 'G #G/ YD YD N#D "#D/

Redundant accidentals omitted

'C "YE 'G #G/ YD D #D "D/

2.1.2:Chords: A chord is defined as a group of notes which begin and end together. We have several notations for transcribing chords: All other forms of simultaneities (e.g., notes of different duration on the same or contiguous stems as well as other overlapping notes) require additional scans.

Methods for spelling chords are roughly divided into spelling by pitch name and spelling by interval.

One converts a string of pitch names into a chord by enclosing them with a pair of the symbol

$ (dollar sign).

In this notation,

1) The current register becomes the register of all pitches in the order transcribed within the chord, until another register is stated; and

2) The register of the first pitch name written after the chord is the current register for pitches that will be written after the chord.

This method is completely straightforward and versatile.

The second method spells chords interval by interval.

The lowest note of a chord is transcribed as a pitch name; thereafter the chord is read in strictly ascending sequence, such that a note at a diatonic interval of an n-th with the previous transcribed note is written n (where n greater than 8 is not allowed). The chord is terminated with

The third method uses a scan movement symbol rather than enclosing symbols. The symbol

> (less than)

following a note indicates that the point of the scan is to be moved to the left a distance equal to the duration of that note. Thus the attack time of the following note will be the same as the preceding. The previously stated register convention applies here also, in fact at all times operating for chords as if they were note successions.

Thus, the triad built on middle C is coded:

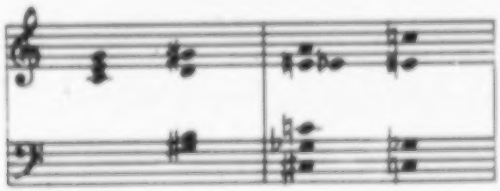
$ C E G $

or C 3 3 >

or C < E < G

Chords

All redundant accidentals and registers omitted



method 1:

$'CEG$ $,#GB'DG$ / $#CYG'NCEYEA$ $"C'NE,GC$ /

method 2:

'C<E<G ,#G<B<'D<G / #C<YG<'NC<E<YE<A "C<'NE<,G<C /

2.1.3:Rests: A rest is written

- (hyphen),

preceded by a duration.

2.1.4:Repeated note-names: One need not explicitly write out each pitch name or chord. If a single note-name occurs several times in succession, or if a sequence of note-names repeats, one can transcribe the section by stating the note or pattern once, then indicating the extent of repetition.

Thus the transcription is condensed and usually clarified.

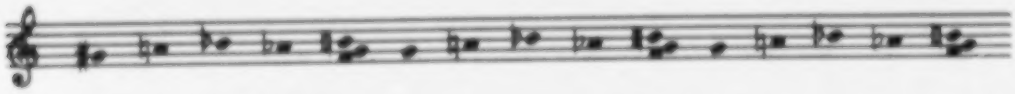
To repeat the previous note name one writes

:K: or K .

To repeat the last n note names one states :Kn: , where n is any positive integer. Further economies are possible but are not considered worth the error risk involved. Further notation for repetitions is introduced in section 4.2.4.3.

Repeated notes

'G K K / $G"XC$KK / $GYB"D$K K /



'♯G NA YB YA $NB G F$ K5 K5

2.2 Durations:

Durations are indicated independently of note names and are interpreted after note name repetitions are expanded. That is, to interpret a coded form of music one first supposes that all note names are written out explicitly by obeying the repetitions implied by K. Then durations are prefixed to each note name, using other repetition notations that permit one, for example, to write out only once a rhythmic sequence which repeats with different note names.

2.2.1:Single durations: The duration of a note, i.e., the interval of time over which it sounds, is indicated by prefixing the note name by one of the digits

0 1 2 4 8 6 3 5 7 .

These serve as mnemonic representations of the following power of 2 durations, respectively: long, whole, half, quarter, 8th, 16th, 32nd, 64th, 128th.

Also, M is a duration number meaning "duration of one measure."

A cue note duration is a duration preceded by

C .

Alternatively, the property of being a grace note or cue note may be stated as an attribute of the note head, in the sense of section 3.

A symbol

. (period)

following a duration has the meaning of the musical dot; namely, the n-th dot increases the duration by one part in 2^n.

2.2.2:Compound durations: Odd-length durations may be constructed from power-of-two durations by tying together two durations with the sign

+ (plus) .

Any number of durations may be combined into a single compound duration. A compound duration occurring in a duration sequence applies to one note-name although the compound duration consists of more than one duration number. (Compare with tie grouping, section 3.)

2.2.3: Cyclic duration definition: Essentially, one must precede every note-name by a duration. However, a particular duration may be omitted if it is the same as that of the previous note. Thus, a single duration applies to the note name it precedes and to each following note name, until a new duration is defined.

More generally, a string of n durations applies one-to-one to n consecutive note names. The string also applies to succeeding groups of n consecutive note names, up to the occurrence of a new duration. Such a sequence of n durations is called a cyclic duration.

We observe that a single duration may be seen as that instance of a cyclic duration for which n is 1.

The notion of cyclic duration provides a convenient means for coding repeating rhythmic patterns.

In summary, a duration is a duration integer possibly preceded by Q and possibly followed by . . A sequence of durations applies cyclically to following note-names, until a new duration appears. Note-name repetitions are expanded before the duration sequence is cyclically applied.

2.3 Expanded phrase:

A phrase is a mixed sequence of note names and durations. An expanded phrase is a phrase written out such that no repetitive pitch definitions and no cyclic durations occur; i.e., every note appears explicitly and is preceded explicitly by a duration.

Durations

2'A 4A 4A /8A8A8A8A 8.A6A6A6A6A6A / 1A /

Omitting redundant durations

2'A 4A A /8 A A A A 8.A 6 A A A A A /1A /

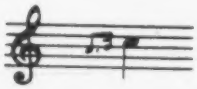
Rests

8'G - 4.- 8'' C 4D /2 - 'G /

Chords

8$'DA''DF$ /4K K 2K /

Cue notes



Q8. Q6 'AB 4"C

Compound duration, tie

4 + 8'B

Cyclic duration

884"E D /D E D D E D /D 2B 8 B A /

2.4 Groupettes:

A groupette on a page of music is a sequence of notes whose individual durations are compressed or expanded such that their total duration takes some specified value. Examples of groupettes are: a triplet of eighth notes in double time, a duplet of eighth notes in triple time.

In ALMA we provide notation for explicitly grouping notes as a groupette; we also allow for groupette durations in a cyclic duration definition. (See also the groupette attribute, Section A5.)

2.4.1:Explicit groupettes: One may state that a sequence of note-names and durations is a groupette by enclosing the sequence of durations and note-names in parentheses preceded by an explicit duration. The effect is to treat the entire expanded phrase within parentheses as a groupette with the duration indicated before the left parenthesis.

Since the durations within the groupette phrase have no independent absolute value (but take their value as a relative proportion of the duration of the groupette), the first note-name in the groupette phrase must be preceded by a duration or cyclic duration.

Durations within a groupette are a lower level than those outside the parentheses in the sense that the duration of the groupette may be implied from a cyclic duration definition (which cycle continues after the groupette). The groupette itself behaves like a single note-chord within the cyclic duration definition.

Groupettes may be nested.

2.4.2:Groupette durations: It is sometimes desirable to indicate as a groupette a sequence of notes whose durations are coded in a cyclic duration definition. For example, to code a passage of triplets eighths, one wishes to state that the durations are triplet eighths before he states any pitch names.

A sequence of groupette durations within a cyclic duration definition may be indicated by enclosing the durations of the groupette in parentheses preceded by the total sounded duration of the groupette. Thus the single duration immediately preceding the left parenthesis does not apply to any note-names in the cyclic definition, but gives the total duration of the groupette, whereas the modified groupette durations apply in sequence to consecutive note-names throughout every repetition of the cycle.

Groupette durations may be nested.

Groupettes

4'F<,A'F<C (8FG A)(8YBA G) / A C (8YBA G) (8AG F) /

or

48'F,A$$'FC$ 4(888)FGA YBA G / 4A C4(888)YBAG A G F /

4(8-,YB'NA<"#C)K+(8KNF< NB,G) /

2.5 Tied notes:

A tie between identical note-names is indicated

+ (plus) .

Note that two durations and two note-names must be indicated, although tied notes are identical to one note--with duration equal to the sum of the durations of the tied notes. (See also compound durations, section 2.2.2.)

"2+8C ,8+6,B 3+8- /

or

"2C+8C,B+6,B3+8- /

3. ATTRIBUTES

In the broadest sense the term "attribute" includes both the notated and inferred properties of notes. Thus, "attribute" includes all the symbols found on the printed page, e.g., pitch and duration symbols (already discussed), dynamics, clefs, key signatures, time signatures, articulations, tempo markings, title, composer's name, etc.; and, in addition, information the coder may wish to express, such as interpretations of ambiguities, performance practices, information culled from previous analysis, and other sources of data.

The following discussion will concern itself mainly with notated properties; inferred properties will take the same form.

3.1 Attribute definition:

An attribute consists of an attribute name followed by scopes in the manner

attribute name _ scopes ,

the whole expression enclosed either in ( ) or * *, depending on the mode of the attribute, defined below.

An attribute name is, in all but a few instances, an arbitrary string of alphabetic symbols. It may not include _ , * , (,) , or = .

The scope of an attribute indicates the notes to which the attribute applies.

A scope may itself be followed by a scope, in the manner

scope ⊥ scope

whereby the second scope indicates the number of times that the first scope is to be executed. (The latter is useful for those attributes whose scopes may repeat, such as the slurring of successive groups of three notes.)

A scope may be one of the following:

n	meaning, attribute name is applied to the following n notes.
n/ or /	meaning, attribute name applies to all following notes up to the nth bar line, or up to the next bar line.
Dm	meaning, attribute name applies to as many following notes as add up to a total duration m.
nDm	meaning, attribute name applies to as many following notes as add up to n notes of duration m.
A	meaning, attribute name applies until the occurrence of the same attribute name with scope of Z.

An attribute is entered at the point of the scan, immediately preceding the first note to which it applies. The insertion of attributes does not move the point of the scan, hence any number may be entered at a given location.

3.1.1:Simultaneous attributes: Several consecutive attributes are assumed to apply simultaneously. Their scopes may overlap and are not required to be the same.

If several attributes apply simultaneously for identically the same scopes, the several attribute definitions may be condensed into one compound attribute, the compound attribute name of the series of attribute names separated by ⊥'s (commas):

attribute name ⊥ attribute name ⊥ etc.

This is followed by scopes, each preceded by a ⊥ , in the manner of simple attributes.

3.1.2:Cyclic attribute definition: In addition, attributes may apply cyclically:

((attribute name ⊥ scope) + ( ) + ( ) ⊥ scope)

denotes a sequence of attributes of different scopes to be applied cyclically, wherein the last scope indicates the number of times that the sequence is to be applied. Scope of 1 is omitted; several scopes separated by ⊥ 's (commas) may be used for any scope in the above.

3.1.3:Scope to the left: The above scopes extend to the right from the point of the scan. Scopes to the left are preceded with

L .

3.1.4:Scope by location: Until now, scopes of attributes have been considered adjacent to the point of the scan. Occasionally one wishes to indicate an attribute with a scope of notes, neither end of which is at the point of the scan. One locates the left end of a scope in the manner

attribute ⊥ location of left end ⊥ scope .

Conversely, one can locate the right end by writing

attribute ⊥ location of right end ⊥ L scope .

Alternatively one can specify the extent of an attribute by explicitly locating both ends:

attribute ⊥ location of left end ⊥ location of right end .

A location of left end begins with FROM followed by symbols indicating distance; A distance expressed in symbols identical to a scope means the point a distance equal to the scope, left from the point of the scan. Other methods of locating left end include:

FROM / n	bar line n
FROM note	the first occurrence of the note or attribute to the left of the present point of the scan
FROM (attribute)	
FROM * attribute *	

Positions to the right of the present point of the scan are indicated by preceding the note or attribute with R, e.g.,

FROM R note .

If one wishes to refer to the n-th note or occurrence of a particular attribute, one writes

FROM (note , n) , FROM ((attribute) , n) ,

FROM R (* attribute * , n) , etc.

Similarly, right hand locations are identified with TO, for example, TO followed a standard scope (meaning a point to the right of the left end if a FROM group precedes the TO, otherwise meaning a point to the right of the present point of the scan). Other methods:

TO / n	bar line n
TO note	the first occurrence of the note or attribute to the right of the left end or the point of the scan
TO (attribute)	
TO * attribute *	

FROM and TO groups with notes indicate scopes including the duration of the note; those with attributes indicate a scope up to but not including the attribute. In summary we see that FROM and TO indicate a temporary relocation of the point of the scan, a relocation applying only to the scope of the attribute currently being located.

3.1.5: Compound scopes: Occasionally one must refer to a scope which is conveniently the sum of two scopes, for example, a scope of a half note duration plus three notes. This example is expressed D2+3. In general, compound scopes are scopes connected by + :

scope + scope + ... + scope .

```
*CL:G**KEY:G**TS:4/4*(B,2,2/+6)((.,2)+(S,2),4)
        8'B "C/XC D  E F  A G  'B "C/E  D 'B  G  G  F4"C+/
                                                (B2,2)8C 'B  A  G
```

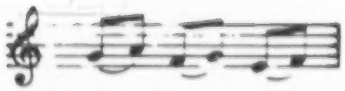
Scopes

Scope of slur

3	(notes)
1/ or /	one barline
D2.	duration of 𝅗𝅥.
DM	duration of a measure
D2+2	duration of 𝅗𝅥 plus 2 notes

Scope of crescendo

5	(notes)
D2 8	duration of 𝅗𝅥 𝅘𝅥𝅮
D2+1	duration of 𝅗𝅥 plus 1 note
FROM, C, TO, G	up to and including, G
FROM, C, TO(.)	up to the statement of attribute (.)



Scope of slurs

2, 3	(2 notes, 3 times)
D4, 3	(𝅘𝅥 , 3 times)

3.2 Attribute modes of application:

An attribute acts in one of two modes, determining the notes to which the attribute applies vertically (as opposed to scope, which indicates horizontal extent). The distinction between the modes is indicated in the choice of symbols enclosing the attribute and its scopes.

3.2.1:The general mode: An attribute enclosed in ** acts in the general mode. Namely, it applies not only to all notes beginning within its scope in the present scan pass, but also to all other notes from subsequent scan passes that begin during the time interval delimited by the scope in the attribute's definition.

Attributes may be easily classified. The value of this fact to the present effort is that a number of classes exhibit the important property of exclusivity:

Of the attributes listed in table 1 (2 pages hence) it may for the most part be said that to a given note only one attribute of a given class may apply at one time. Further, if an attribute of a class occurs at the beginning of a composition, then some attribute of the class will always be present. During scanning, therefore,

the occurrence of an attribute cancels the previously stated attribute of its class (i.e., an attribute is considered "in effect" until the occurrence of another attribute of its class).

In the example on the seventh page, the following attributes (here preceded by their class name) remain in effect through the entire scanning process; others apply only through the first scan:

Composer	-	Beethoven
Title	-	Sonata for Piano Opus 31 No. 3
Movement	-	III
Tempo	-	Moderato e Grazioso
MM	-	4 = 88
Key Signature	-	Three flats
Time Signature	-	3 / 4
Dynamic	-	P
Expression	-	Molto cantabile

Accordingly, the above attributes, whatever the attribute name that will be chosen for each, are enclosed within * *, thus:

* attribute name *

By definition it is not necessary to give such attributes scope: An exclusive attribute defined in general mode remains in effect until the statement in general mode of another attribute from the same class.

3.2.2: Specific mode: Attributes belonging to classes such as articulation and texture operate somewhat differently: Many attributes from each class can be in effect simultaneously. Further, the occurrence of an attribute at the beginning of a composition does not insure that some attribute of its class will always be present.

Such attributes must act in the specific mode and are always enclosed within ( ), thus:

(attribute name , scope) .

When scope is one note it may be omitted, thus:

(attribute name)

An exclusive attribute may be enclosed in either * * or ( ), whichever most conveniently expresses its mode of operation.

An exclusive attribute permanently replaces another only when stated in the same

mode. An exclusive attribute in specific mode replaces the general attribute only during the scope of the specific attribute.

3.3 Attribute names:

An attribute name may be one or more letters in length. (Attributes which have letter names in music notation are usually transcribed in toto, or slightly abbreviated.) The shortest, most mnemonic names are chosen for the most commonly occurring attributes (viz., S for slur, T for trill). The essential criterion for attribute names is that they be unique and unambiguous.

The classification of attributes is accomplished in the metalanguage and need not concern the coder, provided the attribute names he wishes to use are on the standard list. A new attribute name of an existing class may be defined in the metalanguage of the assembler by simply adding its name to the list of attribute names constituting the class; a new class may be defined in the assembler by the statement

(class name = attribute name , , , etc.)

An attribute name may be preceded by a class name and possible higher class names in the manner:

super class name : class name : attribute name.

The class name is useful at the beginning of a transcription, where the largest variety of possible individual attributes can occur. Thus, it is convenient and visually helpful to write:

* CMPSR : MOZART * .

3.3.1:Suggested attribute classes: Table 1 is a list of exclusive class names and their suggested abbreviations:

Composer	CMPSR
Name, Title	NAME, TITLE
Number, opus	NO, OPUS
Instrument	INST
Publisher	PUB
Editor	ED
MS	MS
Key signature	KS
Time signature	TS

M. M.	MM
Tempo	TP
Expression	EXP
Movement	MOVT

3.3.2: Suggested attribute names: The following list of attribute names is suggested:

Dynamics

f	F
p	P
m	M

Meaningful combinations of these, possibly preceded by S, RS, SZ, or followed by : and such special cases as MOLTO, POCO, MENO, etc.

crescendo	CRES
diminuendo	DIM
etc.	

CR followed by :MOLTO, etc.
DCR
CRDCR

Time signature

TS: m_1 / n_1
: $m_1 / n_1 - m_2 / n_2$ etc.,

where m's and n's are numerals.

(The assembler checks whether bar lines are a measure apart, the value of the measure being mDn (etc.) set by the TS attribute.)

Key signature

KS: followed by Y's, #'s, nY, n#
Y or X followed by Pitch names, any of the above possibly followed by MAJ (major) or MIN (minor).

KEY: followed by pitch name followed possibly by #, Y, and/or MAJ or MIN,

TP: followed by any conventional tempo name, or its abbreviation.

Expression	EXP:	as stated in Tempo names such as CONFUOCCO, SECCO, MORENDO etc.
Instruments	INST:	followed by list, each instrument followed also by names such as A 2 DIVISI and separated by commas.
Movement	MOVT:	followed by roman numerals I II III etc., these possibly followed by : and section names.
MM	MM:	followed by Dn = m where Dn is a duration, also Dn = Dm at points of tempo change.
Clef	CL:	followed by G, F, C, TENOR, etc.
	Stave	ST
	Stem (direction)	SD or SU (see section 3.5)
	Right hand	RH
	Left hand	LH
Repeat sign	:/ or /:	
	1st ending	END 1
	2nd ending	END 2
	Dal Segno	DS
	Coda	CO
Double bar	//	
Beam	B	

Texture markings	Slur	S
	Tie	+
	Staccato Dot	.
	Accent	V
	Dash	-
	Glissando	GL
	Arpa	AR
	Tremolo	TM
	Luft pause	LP
	Trill	T
	Turns	W,
	Turns: W, followed by special cases selected for the particular piece.	
Instrumental techniques	PIZZ	
	H (harmonic)	
	COL LEGNO	
	PONTICELLO	
	U or UP BOW	
	D or DOWN BOW	
	PED Pedal	
	REL Release	
Octave doubling	OP with the octave above	
	OJ with the octave below	
Cue notes	Q: only as an indication of notation. Appoggiaturas are best written out explicitly.	
Fermata	FM (see comment on cue notes)	

3.4 Attributes outside delimiters:

The following attribute names may be written outside parentheses in certain situations:

S Slur the previous note name to the following one.

T The next note name is trilled.

3.5 Algorithmic attributes:

The attributes of stem direction and beaming usually constitute highly redundant information, since their use is governed by well defined rules. Thus, in the majority of cases they may be specified algorithmically (in the metalanguage), saving considerable coding time (assuming that the coder has use for this information).

3.6 Conditional (or editorial) symbols:

A string of symbols found in one source and not another may be given an attribute pertaining to that fact. The assembler may be directed to include or delete symbols from any particular source.

A conditional (or editorial) symbol string $\underline{\Theta}$ is indicated by

$$\underline{(}\ \text{name}\ \underline{,}\ \underline{\Theta}\ \underline{)}$$

where name (e.g., the code number of a manuscript) identifies the symbol string $\underline{\Theta}$. The conditional string may be written wherever $\underline{\Theta}$ may be meaningfully used: $\underline{\Theta}$ may be any expression in the language.

The assembler must be told (in its metalanguage) which conditional strings are to be included in any particular translation. That editorial symbols with certain names are included is stated

$$\underline{\text{PRESENT}}\ \underline{=}\ \text{name}\ \underline{,}\ \text{name}\ \underline{,}\ \ldots$$

Alternatively, one indicates that other symbols are to be omitted by stating

$$\underline{\text{OMITTED}}\ \underline{=}\ \text{name}\ \underline{,}\ \text{name}\ \underline{,}\ \ldots$$

A name not present is assumed omitted, or vice versa.

*CL : G**KS : YB**TS : 3/8**F*(S, 12)(B, 6, 2)
6'D E F G A B /#C B A G F E /
(., 6)(B, 3 , 2)8F A" D /'G"#C E /

```
*CL: G**KS: YB**TS: 3/8*(B,3)(.,2)
      8"F   D    'G +/6G"D#C   E  'A "C(B,L6)
                                          /"D'NB(B,L2)(S,L7)T8."#C
                                          6(.)D(B,L2)      /
```

4. *CONTROLLING THE TRANSCRIPTION*

4.1 Scan control:

To describe simple melodic lines, one needs only the symbols of sections 2 and 3. In complex cases, however, one must scan a passage in several passes; hence, before one transcribes later notes he must move the point of the scan.

4.1.1:Scan relocation: The p.o.t.s. (point of the scan) may be relocated either by repositioning it at some fixed reference point or by moving it over a stated distance.

The scan reposition statement

= / m =

means that the pt. of the scan is now immediately to the right of bar line m. Here = / 1 = marks the beginning of the first full measure of a composition. Any notes preceding it are considered to be in = / 0 = .

More generally, the scan can be relocated by a statement

= location =

using locations as defined in section 3.1.2.

4.1.2:Scan movement: Scan movement statements have the form

= direction scope = or duration direction .

Direction is indicated by the symbols

R (right)
L (left) .

Here scope as in section 3.1 defines the distance that the point of the scan is moved. For example,

n , n/ , or / ,

mean respectively, n notes, n bar lines, or the next bar line. When scope is n/ or

2

/, the new p.o.t.s. is always to the right of the n-th bar line from the present p.o.t.s., regardless of direction. When scope is n, the new p.o.t.s. is to the left of the nth note if direction is L, and to the right if direction is R.

Beethoven Sonata (see seventh page).

Without attributes

```
8.,B6E/2E8.G6E/4E4.D8E/
=/1+LD4=
4-/8,GBGBGB/ABABAG/
=/1=
2.,E/2F+8FE/
```

With attributes

```
*CMPSR: BEETHOVEN**TITLE: SONATA FOR PIANO**OPUS: 31**NO: 3*
*MOVT: III:
MINUETTO*
*TP: MODERATO E GRAZIOSO*
*MM: D8 88*
*KS: YBEA**TS: 3/4*
*EXP: MOLTO CANTABILE*
*P*
*CL: G*
(S,B,2)
8.,B6E/(S,3)2E8.G6E/(B,L2)4E4.D8E/
=/1 LD4=
*CL: F*
4-/((R,4)(B,6,2)(S,2DM)8,GBGBGB/ABABAG/
=/1=
2.,E/2F+8FE/
```

In the form = duration direction = delimiters are not required. The distance that the p.o.t.s. is to be moved is given by a duration number. Thus, L and R here behave like note names and take durations according to the duration convention for note names. (However, in spite of this syntactic similarity, their meaning nevertheless remains one of scan move and not one of pitch.)

It will be noticed that, within = =, ( ), and * *, n is a cardinal number, meaning n notes. Outside these delimiters, n is a duration.

4.2 Repetitions:

Portions of the transcription identical to those previously coded may be repeated rather than explicitly rewritten. The general form of a repetition statement is

= repetition scope , extent =

Repetitions include

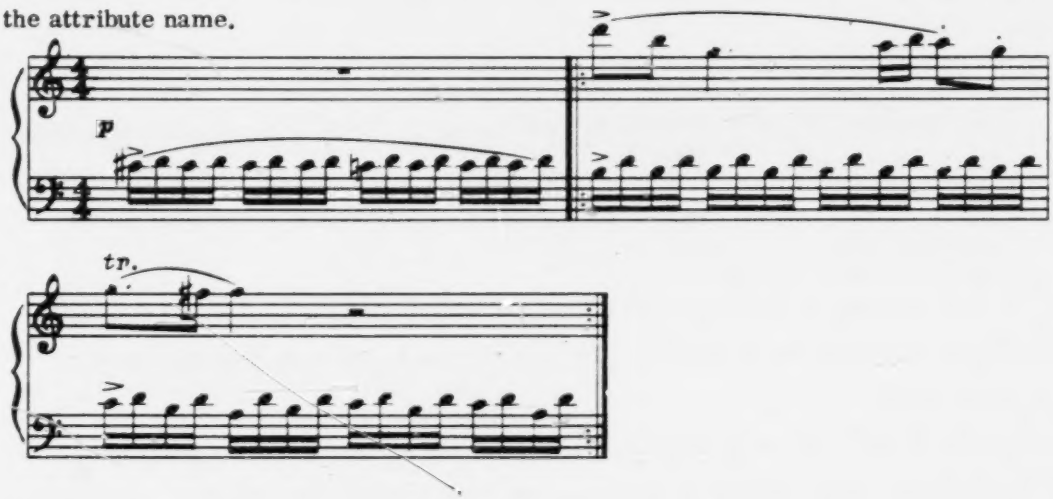
K	repeat pitches
KD	repeat pitches and durations
KA	repeat pitches and attributes
KDA	repeat pitches, durations, and attributes.

Here K indicates that information from the scope of notes is to be repeatedly copied until the extent is fulfilled.

The scope indicates which notes are to be copied. One may specify either a scope relative to the point of the scan, or a scope defined with locations.

The extent is a scope-like condition to be satisfied. For extent, n means n times; other scope notations retain their meaning.

After a repetition statement is obeyed, the point of the scan is positioned as if the symbols had been explicitly written out. Bar lines are added where implied by the current meter signature. In particular, the scan may be repositioned to insert attributes. Or one may use attribute definitions with an initial location preceding the attribute name.




```
*KEY: C**TS: 4/4*
*P*
(S,16)(B,4,4,3)(V)6'#CDCD=K4=NCDCD=K4=//:(V),B'D=K2= =K4= =K8= /(V)CD,B'D,
A'D,B'DCD,B'DCD,A'D://=L/2=
(5,6)(B,2)8'''D''B4.G(B,2)6AB(.,2)8AG(B,L2)/
T(B,2)8.G#F4F(S,L3)2-://
```

APPENDIX

A. EXTENSIONS

A.1 Quarter tones:

As an example of the freedom of the language, we offer the following: Suppose one requires quarter tones. Then, in the metalanguage one states that the legal pitch names are

A B C D E F G

or a pitch letter followed by

H (high)
or L (low)

corresponding to pitches a quarter tone high or a quarter tone low. In the metalanguage one says

quarter change = H or L
quarter pitch = pitch or pitch followed by quarter change.

A.2 Percussion notes:

One can easily augment the pitch table to use Z (or other symbols) to represent percussion note heads.

A.3 Interval with fundamental:

A third method of chord notation spells a chord by stating the interval that each note makes with respect to the lowest note (stated as a pitch name) of the chord.

An integer

n

indicates a note at a diatonic interval n above the lowest note (where n greater than 9 is not allowed). Also, one or more preceding 8's increases the interval a like number of octaves. Each interval is followed by a comma. To indicate accidentals, n may be preceded by appropriate

#, Y, N.

The chord itself must be enclosed within a pair of $.

This method somewhat parallels figured-bass notation.

A.4 Fractional Durations:

To indicate position and scope one may need to refer to durations which are fractions of power - of - two durations, such as the duration of a single groupette note. One m/nth of a duration d is indicated

$$(m \ / \ n) \ d \ .$$

(This can yield 256-th notes. Alternatively, strings of 256ths can be indicated as a groupette.) The proportion of duration d in the ratio of durations d_1 to d_2 is indicated

$$(D \ d_1 \ / \ D \ d_2) \ d \ .$$

(Here d is the sounded duration and d_2 the total duration, if d_1 is a groupette duration whose time value is desired.) Fractional durations may occur in duration sequences for cyclic duration definition.

A.5 Groupette attribute:

Rather than specify groupettes in the manner of sections 2.4.1 and 2.4.2, one can use the following notation: the string

$$n_1 + n_2 \cdots n_k$$

where n's are integers, represent groups of notes, each group having the same total duration. To write a groupette attribute name indicating that the total of all k groups has duration d, one writes

$$G \ n_1 \pm n_2 \pm \cdots \pm n_k \equiv Dd$$

The groupette attribute applies to scopes of notes in the usual way.

Thus, triplet 8th's may be indicated

$$(G3 = D4) \ .$$

The pattern would be written (G4 = D4), since the four notes retain the same relative durations, even when compressed into a shorter total duration. Alternatively, triplet eighths could be coded 1 + 1 + 1 = D4 and the above pattern, 1 + 2 + 1 = D4 .

A nested groupette may be coded by just representing the notes as a sum of cardinals; parentheses indicate inner groups.

This form of groupette notation

1. makes unnecessary the parenthesizing of pitches or cyclic durations.

2. allows the coding of groupettes of any complexity.

A.6 Transliterate:

For example: TRANSLITERATE: A - F indicates that the notes are transcribed so that pitch name A should be replaced by F, B by G, C by A, etc.

A.7 Transpose:

For example: TRANSPOSE: C - YB indicates that all note names should be adjusted such that transcribed C becomes YB, etc; the operation (defined in the meta-language) involves transliterating pitch names and adjusting registers and accidentals to maintain the correct mode and spelling of intervals.

B. ALTERNATIVES

B.1 Relative pitch convention:

The register of a printed note comprises an octave of notes of which it is the central one, i.e., the notes up to and including that at an interval of a fourth (by spelling) above or below it. By definition, each note of the register is the number of its note class closest to the central note. Any note outside the register is considered an octave displacement of one such "closest" note.

Therefore, a note which lies within the register of the previous note is transcribed without register-change symbols. A note n octaves above a "closest" note is transcribed by preceding the pitch name with n of the symbol

' (apostrophe) .

A note n octaves below a "closest" note is transcribed by preceding the pitch name with n of the symbol

,

for the first note of a composition, the "previous" note is understood to be middle C. At any time during a transcription this point of reference may be restored by the symbol

(C) .

A COMPUTER ORIENTED MUSIC NOTATION INCLUDING ETHNOMUSICOLOGICAL SYMBOLS

Jerome Wenker

INTRODUCTION

THE MUSIC NOTATION LANGUAGE

The basic method, at present, of preparing data for the computer involves the use of punched cards, which in turn demands a technique of representing written music using only characters available on the keypunch machine. The term "symbolic music notation" will be used here for the normal form of written music using a five-line staff, clef signs, etc., and the term "character music notation" will be used for the representation of this music notation in terms of letters, numbers and other characters available on the keypunch. This paper is specifically concerned with the problem of designing a character music notation which represents the symbolic music notation containing both the regular music symbols of European Art Music and the special music symbols used by ethnomusicologists.

In designing a character music notation such that the computer can "read" music and "translate" the characters used into numbers representing the pitch, duration and other characteristics of notes and the other symbols of music, certain restrictions must be satisfied. These include: 1) the mechanical limitations of the keypunch machine; 2) a notation which is simple for the keypunch operator to learn; 3) a notation which is mnemonic and "similar" to normal music notation in order that musicians can understand it without having to read a description of the notation system; and, 4) an unambiguous system of notation. Furthermore, the character music notation and the way in which the computer is prepared to handle the notation should be designed such that the computer can translate music rapidly and, if there are errors in the data, detect and correct as many of these as possible. These restrictions are in conflict and compromises must be made; each of these restrictions must be discussed here to show more clearly what is required, what is gained by including the restriction, and how this has affected the final character music

notation itself.

The notation must be simple enough so that it is easy to train keypunch operators, assumed to know nothing about music, to "read" music as if it were a series of "words" to be keypunched. This is not completely possible because, for example, some musical symbols have multiple meanings and must, therefore, be "spelled out" for the keypuncher.

In addition to this the notation must be close to mnemonic so that it can be easily understood by any musician and "translated" back into the original symbolic music notation, or, for single line melodies, sight sung. Two special advantages of designing the notation to be as mnemonic as possible are: first, the notation forms an inexpensive method of publishing simple tunes; and second, it provides a simple method of indexing songs by their first few notes and producing musical incipits for thematic catalogues and the identification of musical sources.

There are also computer oriented conditions to be considered. First, in order that the character music notation described here can be used on all keypunch machines the list of characters which are used in the notation has been restricted to the 26 capital letters, 10 numbers and 11 special characters of the standard IBM keypunch machine. Second, the notation must avoid ambiguities, for if such are present, the computer will have difficulty in determining which musical meaning is desired and will be very likely to make mistakes. Third, the desirable features of simplicity in interpretation by the computer can be considered. This is desirable rather than necessary since it is much easier to have the computer do a moderately large amount of calculation than to train a keypunch operator to do any calculation or analysis. If it is easy for the computer to interpret the notation, the process of converting this data from the human-oriented symbolic music notation used for input and output to the numbers used within the computer will be relatively fast and, therefore, relatively inexpensive. Finally, the character music notation should be designed to simplify the task of the computer in detecting and correcting errors. This error detection and correction provision has been included to limit the number of times the computer might misinterpret a group of characters if one is incorrect. The character music notation given here attempts to satisfy, as much as possible, all of the criteria described above.

Because the character music notation described here was oriented towards perception rather than towards performance, music symbols giving directions to the performer (bowing, tongueing, etc.,) were excluded. This character music notation contains representations for: 1) most of the symbols used in general musicology (see Part Two of this article for the symbols included); 2) all of the special music symbols devised by ethnomusicologists and some logical extensions of their symbols; 3) facilities to alter the meanings of a number of music symbols in order to obtain additional flexibility, and, 4) provisions to make additions to the system.

Although there exists a complete annotated set of computer flow diagrams for this character music notation, it has not been made operational on the computer. However, there should be little, if any, difference between the notation described here and this notation as it would be used on the computer. The lack of a computer program at this time permits additions to be made without requiring expensive alterations of an existing program. Current plans, subject of course to alterations, include the addition to the character music notation of symbols of the symbolic music notation that have not been included here; this additional notation will utilize the same 47 characters used for the character music notation described here and will not alter this notation. The extra 16 characters of the augmented character set of the new IBM Type 29 keypunch machine will be used for the special data required for a computer controlled music orthographic process. These character conventions will permit musicologists interested in analyzing music to prepare their data on a standard keypunch machine; the new keypunch machine will be required only if the musicologist wishes to include music orthography in his data.

By making the additions described above, the notation presented here will contain all music symbols and conventions used since the Renaissance, both in conventional musicology and ethnomusicology, logical extensions of existing musical symbols and conventions, facilities for adding musical symbols and conventions as desired, plus the option of including orthographic information on the music. As a result of the extent and flexibility of this character music notation, even in its present slightly limited form, it can be used as the music notation base for future developments of a musical analysis language.

THE MUSIC ANALYSIS LANGUAGE

A musical analysis language called MUSAN, as envisioned here, would permit the musicologist to instruct the computer to perform any musical analysis he desires in terms of commands similar to written English. The initial design of MUSAN would need to be sufficiently flexible that any existing musical analysis technique used by musicologists or ethnomusicologists could be prepared for the computer by a series of simple statements using English, music notation, and mathematical commands. In many respects MUSAN would need to resemble the FORTRAN and ALGOL computer languages used for the solution of problems in mathematics and physics.

The design of MUSAN is an additional reason for the adoption of a standard character music notation for music input to the computer. The use of MUSAN with a standard character music notation has these advantages: 1) problems can be solved which are too large to be done manually; 2) a large corpus of music can be analysed as easily as a small one; 3) music prepared for one problem can be used as data for the analysis of other problems; 4) different types, styles, or periods of music can be statistically analysed and compared using a significant sample of music from each category; 5) theories of music can be analysed by applying them to significant samples of music; and 6) the computer can be used as a powerful research tool in that the information produced in rejecting one theory can be used to produce a better theory. Because of the scope and flexibility of the character music notation given here, it is recommended that this notation be adopted as the standard language for music input to the computer.

THE CHARACTER MUSIC NOTATION

PRELIMINARY DISCUSSION

The description of the character music notation given here has been arbitrarily divided into three segments: basic music notation; music notation derived from ethnomusicology; and additional music notation. For many music symbols this description consists of a diagram of a musical example containing the music symbols to be presented and, under the diagram, the complete character music notation for the entire example. This presents the notation for each new music symbol, the

proper placement of the notation, and reviews previously discussed music symbols with their notations. Thus to learn the character music notation for any musical symbol the diagram containing the symbol must be compared with the notation given directly below it. All of the musical examples are purely arbitrary and strictly for notational purposes.

The remaining music symbols are discussed verbally and, in most instances, include musical examples. Most of the mnemonics of the character music notation are identified in the text of this article by underlining the first letter of each word supplying a mnemonic letter for the notation. When the character music notation for a music symbol appears in the text it is separated from the preceding word and the succeeding word or punctuation by two spaces; this is done to avoid confusion between the character music notation and punctuation required by the sentence.

To include certain basic variations in notational practice and to make the system more versatile, certain music symbols can be assigned various values; the music symbol retains its normal name and the value desired is chosen by setting a parameter to contain that value. For the human these parameters are normally similar to the description of special notation conventions which precede the music in many ethnomusicological publications. For the computer these parameters are defined by cards which the computer reads before it reads the music to be modified. The machine then sets switches and calculates special substitute values for certain numbers which automatically modify the specific music symbol as specified. Thus, parameters are external to the music notation itself; however, reference is made to the possible presence of parameters at the appropriate places in the description of the character music notation. Because the discussion of the character music notation given here is limited by space considerations to a description of the symbolic music notation along with some information on current plans for future expansion and improvement, full details on how parametric information is prepared for the computer cannot appear here. Some basic information on parameters is given in the discussion of the card formats for music and the identification of the item which follows the description of the character music notation of the symbolic music notation.

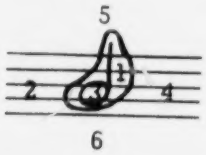
Because the character music notation has been designed specifically for the computer, this article contains a few technical details on the requirements of the

computer. For example, the limited number of characters available has meant that most characters have been assigned multiple meanings; the character music notation has been designed so that the computer recognizes which usage of each character is desired by the context.

In addition to this, certain notational conventions have been devised for the benefit of the user of the system and the computer. The most important character is the comma, used as the basic punctuational symbol. Each independent item of data, each chord, and, if the music has only one voice on a staff, each note is followed by a comma.

Spaces are ignored so they may be used as desired to clarify the data for the human. While the character music notation uses a free format, it has been designed so that the verifying of keypunched cards can be done with little or no problems.

There is a specific arrangement of the many music symbols pertaining to a single note. In symbolic music notation, music symbols pertaining to a note can occur to the left, to the right, above or below the note. In the character music notation all of these symbols must be assigned and described as occurring at some point before, during, or after the note. The sequence of data in the character music notation has been divided into six parts: 1) basic time value; 2) data appearing in the region to the left of the note; 3) basic pitch value; 4) data appearing in the region to the right of the note; 5) data appearing above the note; and 6) data appearing below the note. These regions may be seen in the following diagram. This assigned data sequence will also aid the keypuncher in verifying the cards.

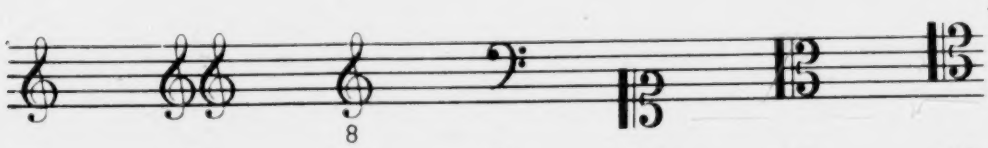


In this diagram the size of regions 1 and 3 have been exaggerated in order to make them visible.

BASIC MUSIC NOTATION

Identification of Staff Type

The clef signature identifies the staff on which the music is written.



GS, GGS, GGS, FS, C1S, C3S, C4S,

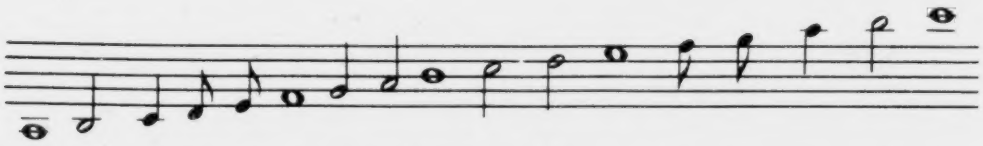
Basic Note Length

Note	Number	Note	Number	Note	Number
𝅝	1	𝅗𝅥	2	♩	4
♪	8	𝅘𝅥𝅯	16	𝅘𝅥𝅰	32
𝅘𝅥𝅱	64	𝅘𝅥𝅲	128	𝅘𝅥𝅳	256

Breve (brevis)	Long (longa)	Large (maximá)
𝅜 or 𝅜 1)	𝅛 1))	𝅚 1)))

The numbers and characters given above to define basic note length are used in the character music notation wherever the basic time value of a note is needed; this includes notes, rests, basic note value in the metronome figure, and so forth. Within the computer the calculated note length ranges from 1/2048 of a whole note to 16 - 1/2048 whole notes in increments of 1/2048 of a whole note.

Basic Note Position

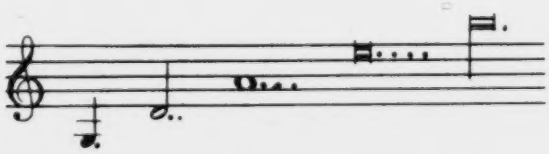


1A-,2B-,4C,8D,8E,1F,2G,2A,1B,2C+,2D+,1E+,8F+,8G+,4A+,2B+,1C++,

Pitches outside of the range of the above diagram require the use of additional plus or minus signs. This notation is mnemonic as long as the G clef is used; the same positional notation is used regardless of the clef sign leaving the computer to do all transposing.

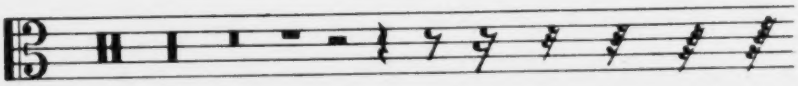
The normal subdivisions of the semitone is into "cents" where 100 cents equals one semitone or into "savarts" where 301 savarts equals one octave. Although the computer can handle values given in savarts, all computations and discussions here will be given in cents. The computer can handle pitches as low as 15.43 cps (.390625 cents above the B four octaves and a semitone below middle C) and as high as 25,570 cps (.390625 cents below the B sharp six octaves and eight semitones above middle C) in equal intervals of .390625 cents.

Dotted Notes



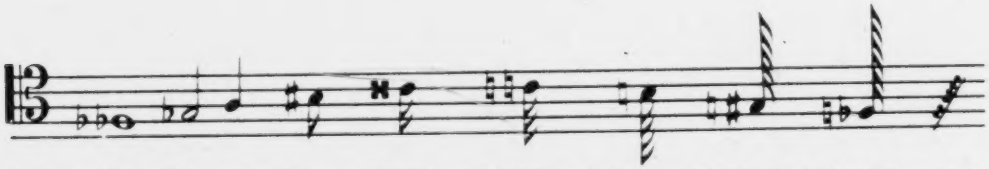
GS,4G-.,2D..,1A...,1)E+....,1)))B+.,

Rests



C3S,1)))R,1))R,1)R,1R,2R,4R,8R,16R,32R,64R,128R,256R,

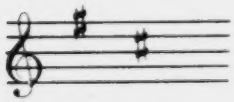
Accidentals and Naturals



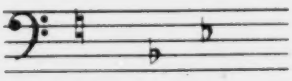
C4S,1$$G,2$A,4B,8*C+,16**D+,32NND+,64NC+,128N*A,256N$G,256R,

Special values of the pitch alteration produced by a sharp, flat, double sharp, etc., can be used if desired.

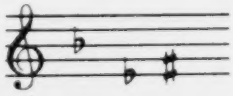
Simple Key Signatures



GS,K*F+,*C+,K,



FS,KND+,$G,$C+,K,



GS,K$B,$E,*F,K,

The characters K0K, [K zero K] can be used to delete a key signature or to explicitly state that there is no key signature.

Time Signatures

Signature	Notation	Signature	Notation
$\frac{2}{4}$	2=4,	C	4=4,
$\frac{3}{4}$	3=4,	¢	2=2, or 4=2,
$\frac{4+3}{8}$	4+3=8,	$\frac{4}{4}$ $\frac{15}{16}$	4=4J15=16,
$\frac{3\frac{1}{2}}{4}$	3.5=4,	$\frac{7}{8}$?	7=8Q.

The characters 0=4, [zero = 4] can be used to delete a time signature or to explicitly state that there is no time signature.

In most music written in Western Music notation certain time signatures imply points of secondary accent within the measure. The computer marks notes with these secondary accents; this indication can be skipped or altered, if desired.

The Metronome Count

M 𝅗𝅥 = 60	M. M. 𝅗𝅥. = 100	M ♪ = 125-150
M2=60,	M4. = 100,	M8=125-150,

Bar Lines

Bar lines are represented by /, ; the double bar line used at the end of a section of music is represented by //, .

End

The end of the piece of music is indicated by keypunching END as the final set of characters.

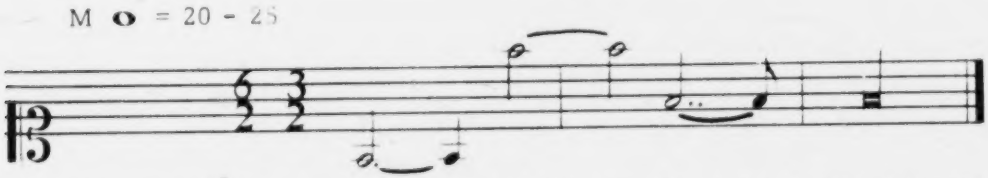
Grace Notes

Each grace note is marked to indicate that it obtains its time from a preceding or succeeding note.

GS,4=4,2E.,16P*F,8PA,4E+,8PC+,/,16SC+,4E+,16SA,8SNF,2E.,//,END

Tied Notes

The letter J is used to indicate that one note is joined to a following note of the same pitch.



C1S,M1=20-25,6=2J3=2,2A-.J,4A-,2A+J,/,2A+,2A..J,8A,/,1))A,//,END

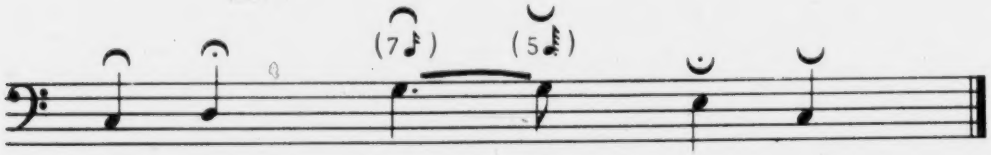
Held Notes

The fermata indicating that a note is to be held longer than its time value permits is represented in the character music notation by H+H . The music symbol ⌒ which indicates that a note is to be held longer than its time value permits but not as long as ⌒ is notated by H++H .

The music symbol ◡ which has the inverse function of ⌒ is notated by H-H ; similarly, the symbol ◡ which shortens the playing time of a note by a small amount is notated by H--H .

Some transcriptions indicate the value used with a note to be held or shortened by giving the exact time value in parentheses below the hold sign and above the note whose time value is to be modified. This exact time value is indicated in the symbolic

music notation as a whole number followed by a miniature note which gives a basic time value; the exact time value is equal to the given number multiplied by the time value of the given note.



FS,4AH++H,4BH+H,4E+.JH7K16H,8E+H5K64.H,4C+H-H,4AH--H,//,END

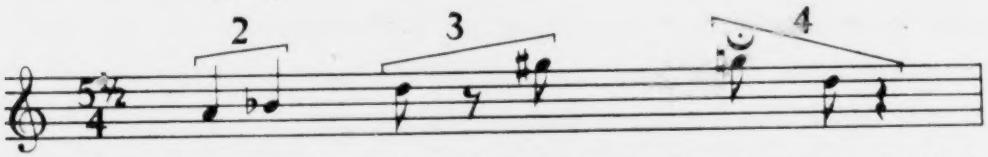
The amount by which held symbols lengthen or shorten the time value of a note can be defined as desired.

Triplets

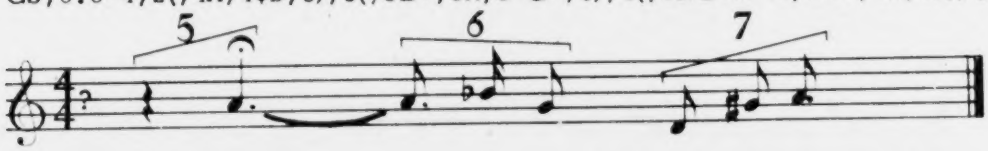
The term "triplets" is used to cover all divisions of time whereby a series of notes and rests adding up to m units of individual time value p are played in the time in which n units of that time value would be played, as indicated in the following table.

Title	Number Printed with the Music	m	Units to be Played in the Time of n Units
Duplets	2	2	Units to be played in the time of 3 units
Triplets	3	3	Units to be played in the time of 2 units
Quadruplets	4	4	Units to be played in the time of 3 units
		8	Units to be played in the time of 6 units
Quintuplets	5	5	Units to be played in the time of 4 units
Sextuplets	6	6	Units to be played in the time of 4 units
Septuplets	7	7	Units to be played in the time of 4 units

The notation used for these modifications of time values consists of two parts. The number of units present followed by (is used preceding the first of these units. The characters 3) are used following the last unit to be modified.



GS,5.5=4,2(,4A,4$B,3),3(,8D+,8R,8*G+,3),4(,8NG+H-H,8D+,4R,3),/,



4=4Q,5(,4R,4A.JH+H,3),6(,8A.,16$B,8G,3),7(,8D,8*G,8A.,3),//,END

Some musicians use notes of double length for "triplets" thus producing, in the case of "two units to be played in the time of three units," for example, "two units to be played in the time of one and one-half units." The data is keypunched as it appears on the staff and the problem of the true note length is solved by use of a switch set within the computer by a card which the computer reads before it reads the music.

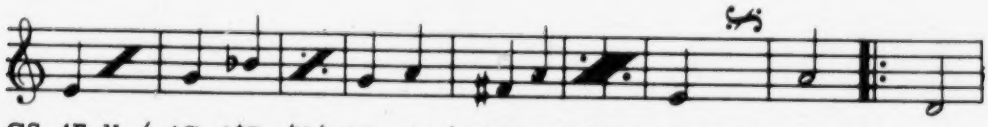
Repetitions

The repetition symbols , , and are used when very short sections of music are to be repeated. The first is notated by X, , the second by /X/, , and the third by /XX/, . The remaining repetition symbols are all notated using a T to indicate that a section of the music is to be performed twice. The music symbol is represented by T(, ; the music symbol by T), ; and the music symbol by T)/T(, . Since these symbols do not always occur at a bar line, the bar line must be indicated where apropos, thus producing the character sequences T),/, , T(,/, and T),/,T(, .

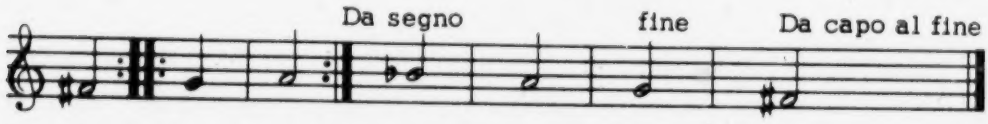
The segno symbol ( ) is given in the character music notation by TST, ; the word "fine" by TFT, ; "Da segno" and "D.S." by TS), ; "Da capo" and "D.C." by TT), ; "Da capo al segno" by TTS), ; and "Da capo al fine" by TTF), . When the symbols are used at bar lines, the bar line must also be included.

Sometimes a section of music to be repeated has two endings indicated by the music symbols 1 called "prima volta," for the first ending, and 2

called "seconda volta" for the second ending; these are indicated by T1), and T2), respectively. The completion of the first ending is indicated by the occurrence of the T2), characters. The final symbols related to repetition are ⊕ and "Coda"; the notation used for these symbols is also T1), and T2), respectively.



GS,4E,X,/,4G,4$B,/X/,4G,4A,/,4*F,4A,/XX/,2E,TST,/,2A,T(,/,2D,/,



2*F,T),/,T(,2G,/,2A,T),/,2$B,TS),/,2A,/,2G,TFT,/,2*F,TTF),//,END

MUSIC NOTATION DERIVED FROM ETHNOMUSICOLOGY

Some music symbols do not normally occur in Western European art music, but are used with relative frequency in ethnomusicological and some folksong studies. Since these symbols are not commonly used, additional verbal discussion and diagrams will be required in this section of the description of the character music notation. Because many of these symbols are seldom used and because of the limited number of characters available, only about half of these symbols can be represented in mnemonic form.

The first section of these ethnomusicology symbols to be discussed are those that modify the pitch of notes. Among these are the music symbols which raise or lower the pitch of a note by an exact, fixed amount. In terms of the type of notation and how it is used, these symbols are like accidentals and, because most of them modify pitch by less than a semitone, they will be called micro-accidentals here. For descriptive purposes, these symbols are arbitrarily divided into two groups; the first of these is called "Quarter Tone Micro-Accidentals" and is concerned with the relatively common music notation used for quarter tones. The second group is

called "Other Forms of Micro-Accidentals" because it is concerned with all other symbols used to indicate the modification of pitch by exact, fixed amounts.

Quarter Tone Micro-Accidentals

A quarter tone is a note whose pitch value is exactly half-way between two adjacent pitches of the tuning system used in Western European art music. Since various musicians use different means of indicating quarter tones several such notations are included in the following table.

Name	Symbols Used			Character Music Notation
Quarter tone sharp	♮	♯		(+4)
Quarter tone flat	♭	R	♭/2	(-4)
Three-quarter tones sharp	♯	♯		*(+4)
Three-quarter tones flat	♭	R♭		$(-4)

The computer normally treats as identical a pitch which is raised by a quarter tone and the next higher semitone lowered by a quarter tone. However, the values assigned to the quarter tone symbols can be changed, if desired.

The natural sign cancels both sharps and flats and quarter tone symbols. Unless an accidental, natural or a second micro-accidental occurs, the quarter tone symbol will hold over to the end of the measure in the same way that sharps, flats, and naturals are used. Quarter tones form a part of the general subject of micro-accidentals; for examples of quarter tones and further details see the following topic.

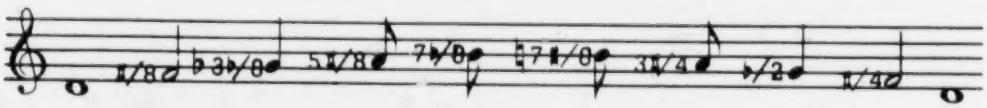
Other Forms of Micro-Accidentals

In some cases, it is necessary to use a notation which permits the division of a semitone into smaller units than a quarter tone. For this purpose the character music notation has been set to divide a semitone into eight parts and special symbolic music notation symbols have been devised to indicate these subdivisions. These special symbols and their character music notations are:

♯/8	♯/4	3♯/8	♯/2	5♯/8	3♯/4	7♯/8
(+1)	(+2)	(+3)	(+4)	(+5)	(+6)	(+7)

♭/8	♭/4	3♭/8	♭/2	5♭/8	3♭/4	7♭/8
(-1)	(-2)	(-3)	(-4)	(-5)	(-6)	(-7)

When these symbols appear with one note their effect continues to the end of the measure unless an accidental, natural or another micro-accidental occurs. The usage of these symbols, which include the quarter tone micro-accidentals discussed above, appears in the following diagram:



in which the pitch positions are read as "D, F one-eighth sharp, G one and three-eighths flat, A five-eighths sharp, B seven-eighths flat, B seven-eighths sharp, A three-fourths sharp, G one-half flat, F one-fourth sharp, D"; this notation appears in the character music notation as in the following line.

GS,1D,2(+1)F,4$(-3)G,8(+5)A,8(-7)B,8N(+7)B,8(+6)A,4(-4)G,2(+2)F,1D,

Unless otherwise specified the exact pitch modification used in the computer for each of these symbols is 12.5 cents multiplied by the number given within the parentheses. If desired, any of these symbols can be set to any value required by music notation using specified pitches not given in normal music notations. Thus there will be no difficulty in using the computer for music using pythagorean commas, limmas, apotomes, etc.

Estimated Pitch Modifications

The preceding topics have dealt with symbols used to indicate that a pitch has been raised or lowered by a specific amount. While such precise transcriptions are relatively rare, symbols are used to indicate that some alteration of pitch occurs. The term "Estimated Pitch Modifications" is the title employed here for the various notations used by ethnomusicologists to indicate that the pitch of a note is to be raised or lowered without specifying the exact amount of pitch modification.

The usual symbol to indicate that a pitch is to be raised is either a + or a ↑ written above the note; the usual symbol to indicate that a pitch is to be lowered is either a - or a ↓ written above the note. The symbols ++ and -- have been used to indicate that the note is to be raised or lowered by a larger amount than that indicated by + or - .

GS,6=4,4D(++),4*F(+),8G(+),8C+(--),8C+(-),4G.JH+H(-),4G(-),//,END

In symbolic music notation these symbols indicate that the pitch is to be altered in a particular direction but do not give a precise value for the amount of this alteration. It has arbitrarily been decided that for the computer the normal case is that in which these symbols do alter the pitch of the note. For this purpose arbitrary values have been defined as follows:

Notation	Change in Pitch	Notation	Change in Pitch
(+)	+18.75 cents	(-)	-18.75 cents
(++)	+31.25 cents	(--)	-31.25 cents

If desired, the computer can mark the note as containing the estimated pitch modification symbol without altering the pitch or use different values for the pitch alteration effected in the computer.

Absolute Pitch Specifications

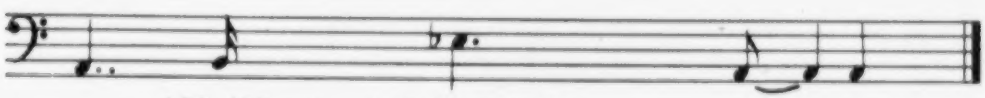
This topic consists of three methods of specifying the exact pitch of a note: 1) the pitch of a note is to be modified by a specific number of cents; 2) the pitch of the note is defined to be a specific number of cents above or below the preceding note for this voice; and 3) the pitch of the note is defined by its exact frequency expressed in cycles per second.

If the exact pitch of a note is specified by modifying its basic pitch the character music notation is (M= , followed by + indicating that the pitch is raised or -

indicating that the pitch is lowered, the value of the modification, and C) indicating that this value is in cents or S) indicating savarts. The computer takes the pitch of the note as defined by the other character music notations and adds or subtracts the value of the pitch modification requested to produce the final pitch value of the note.

If the pitch of a note is specified by giving the exact interval between this note and the preceding note, the character music notation is (I= , followed by + indicating an ascending interval or - indicating a descending interval, the value of the interval, and C) for cents or S) for savarts. The computer uses only the exact pitch of the preceding note for this voice and the given interval to calculate the final pitch of the current note; this means that every other pitch indicating notation of the current note, including the basic note position, will be ignored. However, a basic note position must be given in the character music notation to enable the computer to recognize the note.

If the pitch of a note is defined by its frequency, the character music notation consists of (P= , followed by the pitch of the note given in cycles per second and) . The computer uses this pitch value as the final pitch of the note and ignores every other pitch indicating notation for this note including the basic note position. Again, a basic note position must be given in the character music notation for the computer.



123.456 cps + 2.03 savarts

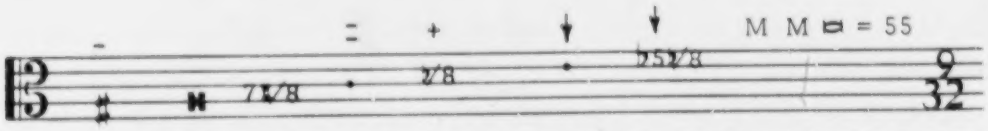
← 602 cents →

FS,4F..,16G(P=123.456),4$C+.(M=+2.03S),8FJ(I=-602C),4F,4F,//,END

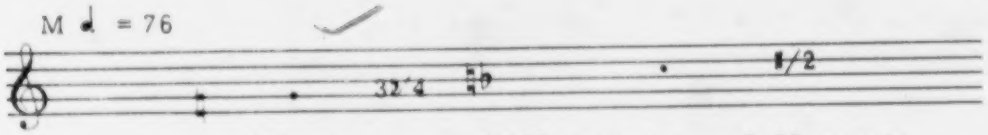
Complex Key Signatures

The notation of a key signature is K , followed by the data pertaining to every pitch position which is to be altered where the data pertaining to one pitch position is separated from the data pertaining to other pitch positions by commas, and K, . For the complex key signatures discussed here, the data pertaining to a pitch position can contain several types of pitch modifying symbols. The symbols used in complex key signatures and the sequence in which they are presented in the character music

notation are: 1) accidentals or naturals; 2) micro-accidental; 3) basic pitch position which must be present; 4) estimated pitch modification data; and 5) absolute pitch specification data. The sequence of data presentation used here for key signatures is exactly the same as that used for notes.



C3S,K*F(-),**G,(+7)A,B(--),(-1)C+(+),D+(-),$(-5)E+(-),K,M1)=55,9=32,



420 cps ←186 cents→ - 3.33 savarts

GS,M4.=76,KNF,G(P=420),(-6)A,N$B,C+(I=+186C),(+4)D+(M=-3.33S),K,

Accidentals and micro-accidentals occurring in a key signature are assumed to apply to all octaves; they can be altered by use of a natural, accidental or micro-accidental. The pitch of notes is determined by one of two rules: 1) if there is no accidental, natural, or micro-accidental preceding a note appearing in the same octave and measure, the key signature controls any modification of pitch; and 2) if there is such a symbol preceding the note, then the symbol controls the pitch.

The symbolic music notation does not have, and usually does not need, a "natural" sign for either an absolute pitch specification or an estimated pitch modification symbol. This means that pitch positions defined in a key signature which use either of these two types of symbols require special consideration.

For the character music notation this special consideration is interpreted as follows: where the special pitch is defined in the key signature it affects only the notes which use the identical letter value, octave, and accidental or micro-accidental. For example, if the key signature sets the note A to a special pitch value, through the occurrence of an absolute pitch specification or an estimated pitch modification symbol, then this setting will <u>not</u> alter the pitch of A sharp, A flat, A sharped or

flatted by a micro-accidental, B double flat, or A in a different octave. By defining special pitches in this manner, it is possible to avoid using them if this is desired.

When the absolute pitch specification data for a particular note is given by either the frequency of the note or an interval between the note and its predecessor, key signature information is ignored. When the absolute pitch specification is a modification of the previously calculated pitch of the note, then the key signature information must be used.

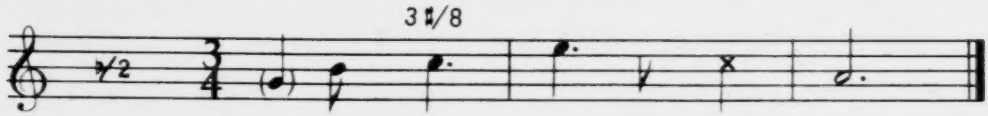
Special pitches required for a piece of music can be set up in the key signature and then automatically used throughout the piece of music without the necessity of further reference. This facility is especially useful for music played on instruments of fixed pitch, since the pitches of the instruments can be given to the computer in the key signature at the beginning of the piece of music, and the actual transcription can be written without using any pitch modifying symbols.

Indefinite Pitch

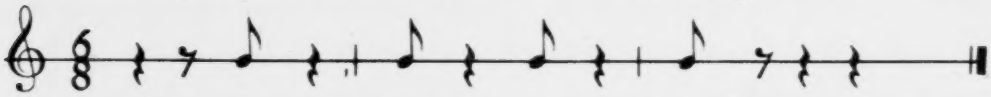
Notes of indefinite pitch occur in some transcriptions due to limitations caused by indistinct notes, or to the way in which the sound was produced. These notes are usually represented by ♩ , ♪ , or by (♩) . All of these are represented in the character music notation by use of the letter X .

There are also musical sounds which have a time value but no pitch, such as hand clapping, castanets, etc. Because they have no pitch, these "notes" are sometimes written on a separate one-line "staff", or on a staff which does not have a clef sign. For the purposes of the character music notation this staff is arbitrarily identified by use of the G clef, and the "notes" use XX in place of X .

Other notations which show that the pitch of a note can be considered to be indefinite include placing an accidental, natural, micro-accidental, estimated pitch modification in parentheses above or to the left of the note. For the character music notation these symbols are indicated by including both the accidental, natural, micro-accidental or estimated pitch modification symbol and the letter X .



GS,K(-4)B,K,3=4,4XG,8B,4(+3)XC+.,/,4E+.,8XD+,4XC+,/,2G.,//,END



GS,6=8,4R,8R,8XXG,4R,/,8XXG,4R,8XXG,4R,/,8XXG,8R,4R,4R,//,END

Attacks and Releases

In some music the performer begins below or above the pitch desired and then slides up or down to it; this mode of attack is indicated in music transcriptions by the use of a short diagonal line running up or down, placed on the left of the note, that is, , or . Similarly a slide up or down at the end of a note is called a release and is indicated in transcriptions by use of similar diagonal line placed to the right of the note.

GS,8G,8I-I*F,4G..I+I,16*AI-I,/,8SI+IXE+,4B,8G+I-IH+H,4G+.,//,END

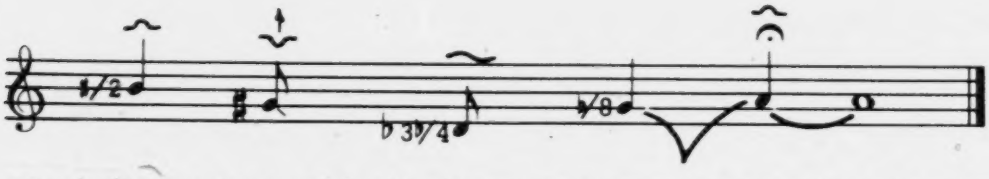
Bends and Dips

A bend is defined as a note which starts at one pitch, rises by a small amount, and then returns to the original pitch. A dip is defined as a note which starts at one pitch, falls by a small amount and then returns to the original pitch. Notations used for a bend are and ; notations used for a dip are and .

Some musicians use the pitch at the end of this complex note as the basic pitch value, while others use the pitch at the middle. It is arbitrarily assumed that the "normal" case is that where the pitch is given for the end of the note. If this is not the case the computer can be set to raise or lower the given pitch by a specific number of cents to normalize it according to the convention given above.

The music symbol ~ written above a note in jazz notations is also called a

bend; it indicates that there is to be a dip at the end of the note, that is, the pitch pattern is instead of the of a normal dip. The music symbol is called a dip and appears in jazz notations between two notes to indicate that the pitch of the end of the first note drops an indeterminate amount and then rises to the pitch of the second note. In the character music notation it is notated for the first note: the computer will mark the next note for this voice as being preceded by the jazz dip symbol.



GS,4(+4)BIBI,8*GI-IIDI(+),8$(-6)DIBJI,4(-1)GIDJI,4AJH+HIBI,1A,//,END

Portamento

The term portamento is used when the pitch of one note rises or falls smoothly to the pitch of the next. Although the music notation differs, the acoustic phenomenon of portamento is similar to that of an exaggerated release on one note becoming an exaggerated attack on the next with no perceivable separation between them. This phenomenon is to be distinguished from a "glide" which is more correctly described as a chromatic run between two notes.

GS,4=2,2APH++H,4(-2)BP,4E+,2NB.PH-H(-),4$G,/,1)AH+H,TT),//,END

Unstable Passages

Some transcriptions include the notation of variations in the performance of certain notes or full measures of the music. These unstable passages are normally indicated by identifying the passages and giving the variations at the end of the melody. Frequently the measures of the main piece of music are numbered with

the measure following the first bar line receiving the number one; each variation is given in complete measures and the position of the variation in the main piece of music is identified by giving the numbers of the first and last measures to be replaced.

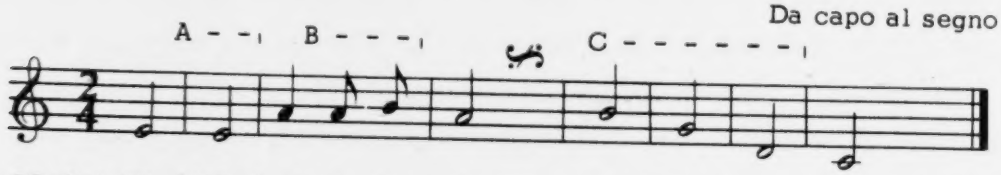
When this is the case, the character music notation identifying the beginning of an unstable passage consists of UB , followed by the number of the first measure to be replaced, and by a comma. This notation is placed following the bar line identifying the end of the previous section of music and before the start of the data on the unstable passage. The end of an unstable passage of music is indicated by UE , followed by the number of the last measure to be replaced, and a comma. If the clef signature, key signature, or time signature in use before the beginning of the unstable passage is not that desired for the unstable passage, the correct signature(s) must be given before the notes and rests of the unstable passage. If the clef signature must be changed it will also be necessary to give the key signature since the definition of the key signature uses information from the clef signature. If the unstable passage is assigned to any staff number other than the current one (see the topic "Multiple Staffs" below), the correct staff number must precede the unstable passage data; in this case the staff number appears in the symbolic music notation.

Other methods of indicating unstable passages exist, the most common of which consists of marking the passage by a number, letter, or other special non-musical symbol and repeating this symbol at the end of the music along with the variant music passage. A second method consists of adding a short staff above the music and placing the variant on this staff.

The character music notation handles both of these methods by identifying the measure number in which the unstable passage begins and the number of the note or rest[1] within the measure. The beginning of an unstable passage cited in this manner is notated by UB , followed by the measure number, J , the number of the first

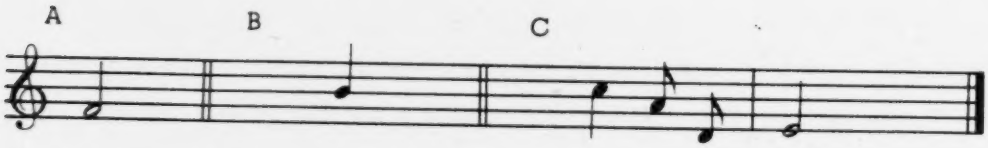
[1] For music with "Multiple Voices on a Single Staff" (discussed below) the number of the "note cluster" will be used instead. The computation of the number of the notes, rests, or note clusters in the measure and the number of the measure in the piece of music requires some additional work. However, the counting of measures, notes, etc., is a sufficiently mechanical task that the keypunch operator should be able to handle it, especially since most songs containing variations are relatively short.

note for which the unstable passage presents an alternative, and a comma. Similarly, the notation for the end of an unstable passage is UE , followed by the measure number, J , the number of the last note for which the unstable passage presents an alternative, and a comma. If only one note is to be altered, the measure and note numbers following the UB are the same as those which follow the UE .



GS,2=4,2E,/,2E,/,4A,8A,8B,/,2A,TST,/,2B,/,2G,/,2D,/,2C,TTS),//,

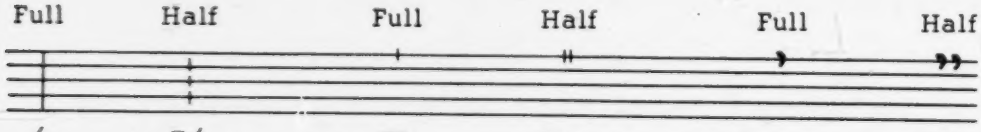
Variations



UB1,2F,UE1,//,UB2J2,4B,UE2J3,//,UB4,4C+,8A,8D,/,2E,UE6,//,END

Phrase Marks

In some transcriptions music symbols appear which indicate the phrase divisions of the music; these symbols consist of two types, one that indicates the end of a full phrase and one that indicates the subdivision of the phrase. There are three different symbolic music notations for these symbols. Because the symbol used in one of these notations to mark the end of the full phrase duplicates the bar line, two different character music notations are required.

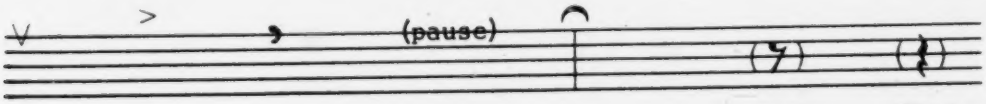


/, Z/, ZL, ZLL, ZL, ZLL,

To indicate that the phrase mark may be questionable, Q can be given just before the comma, thus producing the notations Z/Q, , ZLQ, , and ZLLQ, .

Breath Marks

The phrase marks discussed above are often indicated by the breathing of the performer; such short rests, which do not have rhythmic significance (Atempause), appear in some transcriptions through the use of special music symbols. A second form of breath pause consists of either the word "pause" written between notes or a hold sign placed over a bar line. The exact length of a breath pause can also be indicated by a rest symbol placed in parentheses.



ZB, ZB, ZB, ZP, ZP, ZR=8, ZR=4,

The letter Q can be included in the character music notation just before the comma to indicate that a breath mark symbol is questionable. This produces such character music notations as ZBQ, , ZPQ, , ZR=8Q, , and ZR=4Q, .

Transcriber's Pitch Transposition

For certain types of music analysis, songs which originally were performed at one pitch level are published at a different pitch level. When this arbitrary transposition occurs, the information is frequently given with the transcription by noting the number of semitones of pitch alteration followed by the letter U , if the original was at a higher pitch than the transcription, or the letter D , if the original was at a lower pitch than the transcription.

A second and much more common method of indicating pitch transposition consists of printing a small note before the clef sign; this gives the true pitch of the first note of the music. Unfortunately in this case the character music notation requires that the number of semitones of transposition be counted which requires work

by the musician or additional training of the keypunch operator.

U=-8, U=+22, U=+7, U=-15,

It is possible that the transposition used cannot be expressed precisely in semitones. In such cases the character music notation consists of U= , followed by + or - , the value of the transposition, and by C, indicating cents or S, indicating savarts.

ADDITIONAL MUSIC NOTATION

Trills

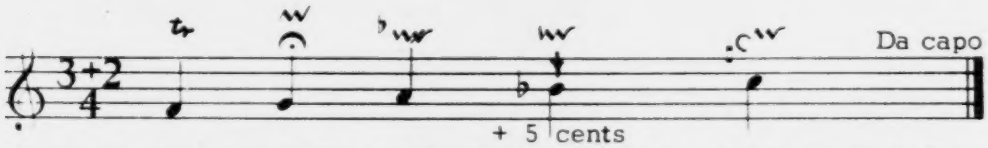
The term "trills" as used here includes trills, turns, mordents, and tremolo notations. The symbolic music notations tr , tr , , and t which appear above a note all have the same meaning and are notated by Z1 . The following table lists all the remaining trill symbols excepting tremolo with their equivalent character music notations.

Symbol	Notation	Symbol	Notation	Symbol	Notation
	Z2		Z6		Z9
	Z3		Z7		Z10
	Z4		Z8		Z11
	Z5				Z12

When the interval between the given note and the trill note above it is to be one or three semitones instead of the standard two semitones, an accidental or natural is placed above and to the left of the trill symbol. In the character music notation this accidental or natural follows the number designating the trill symbol employed.

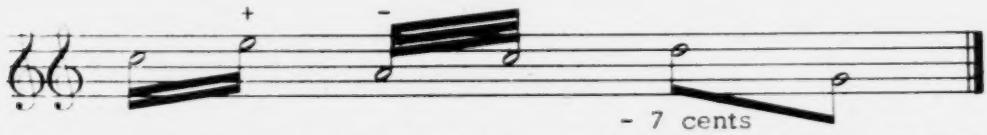
When the interval between the given note and the trill note below it is to be

one or three semitones instead of the standard two semitones, an accidental or natural is placed below and to the left of the trill symbol. In the character music notation this is indicated by a minus sign following the accidental or natural. To maintain symmetry in the character music notation the plus sign may be used to indicate that the trill note above the given note is to be altered; thus Z1$ is equivalent to Z1$+ .



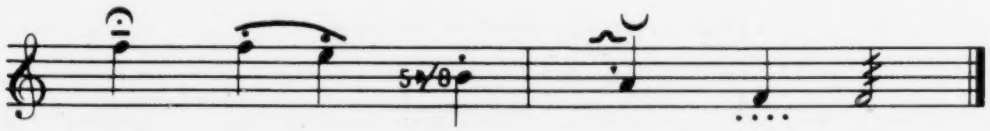
GS,3+2=4,4FZ1,4GH+HZ2,4AZ4$,4$B(-)Z6(M=+5C),4C+Z8N-,TT),//,END

The only remaining trill symbol is the tremolo, notated by Z15 . The time values for the two notes involved in the tremolo must be such that their sum equals the total time used in performing the tremolo because the computer calculates the total time elapsed during each measure in checking for errors in keypunching time values. The first note will be given the time value of each note performed in the tremolo and the second note will give the remaining time used in performing the tremolo passage.



GGS,16C+Z15,4E+..(+),32A(-)Z15,4C+...,8D+Z15(M=-7C),4G.,//,END

Indications to Performers

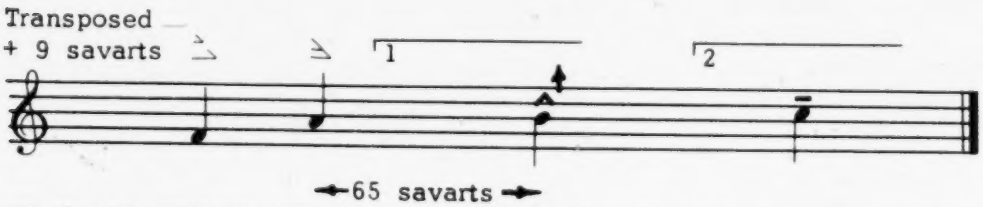


GS,4F+H+HV1,4F+V2,4E+V2,4(-5)BV3,/,4AH--HV4IBI,4FV5,2FV7,//,END
leggiero portato staccato staccatissimo tremolo

Dynamic Accentuation

Most of the music symbols discussed in this topic are used to indicate the relative volume of sound produced by the performer; they can occur either with reference to a single note or to a series of notes. To distinguish between these usages certain conventions have been prepared for the character music notation. When these symbols refer to a series of notes, the character music notation is separated from the preceding and succeeding data by the usual commas. When these symbols are used for a single note, the character music notation appears in the data pertaining to the note.

For the arbitrary symbols for which no mnemonic meaningful to the non-musician could be created, the character music notation consists of W , followed by an arbitrary number, and W .



GS,U=+9S,4FW1W,4AW2W;T1),4B(+)W3W(I=+65S),T2),4C+W4W,//,END

The remaining dynamic accent symbols are ones for which mnemonic notations can be utilized. The first of these consists of the equivalent music symbols sf , > , and sfz all of which are notated as WSFW . The second consists of the equivalent music symbols rf , rfz and rinf notated as WRFW . The

remaining dynamic accent symbols, other than crescendo and decrescendo, appear in the following table.

Symbol	Notation	Symbol	Notation	Symbol	Notation
ppp	WPPPW	*sfp*	WSFPW	*fff*	WFFFW
pp	WPPW	*fp*	WFPW	*ff*	WFFW
p	WPW	*mp*	WMPW	*f*	WFW
		mf	WMFW		

In some transcriptions dynamic accent signs are placed in brackets or parentheses to indicate that these accents are either unclear or subjective. The notation used for this consists of adding Q for questionable immediately preceeding the second W .

- 9 savarts

GS,4CWSFW,4DWRFW,WMFW,4E,4F,4GZ3W2QW(M=-9S),WMPQW,2C+,

Crescendo and Decrescendo

Crescendo and decrescendo symbols have been separated from other dynamic accent notation because these two music symbols have specific beginning and ending positions normally indicated by the notation.

WCBW, crescendo--begin

WCEW, crescendo--end

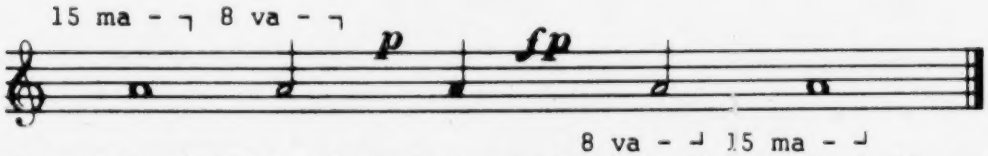
WDBW, decrescendo--begin

WDEW, decrescendo--end

When the symbolic music notation uses the abbreviations cresc. , decresc. , or decr. the character music notation remains WCBW, and WDBW, . Unless otherwise indicated it is assumed that the end of one of these crescendo and

decrescendo symbols occurs when the next crescendo or descrescendo for this staff begins. The character music notation and the computer permit the use of Q immediately preceding the final W to indicate that the crescendo or decrescendo is questionable or subjective.

Octave Transposition



GS,VV+(,1A,V),V+(,2A,V),WPW,4A,WFPW,V-(,2A,V),VV-(,1A,V),//,END

Long Rests

When an instrument or voice is silent for a period of several measures, a single whole rest is used with the number of measures of silence desired appearing above the rest. For such long rests the character music notation consists of LR , followed by the number of measures of silence required, and a comma. In normal usage this music symbol is preceded and followed by bar lines.

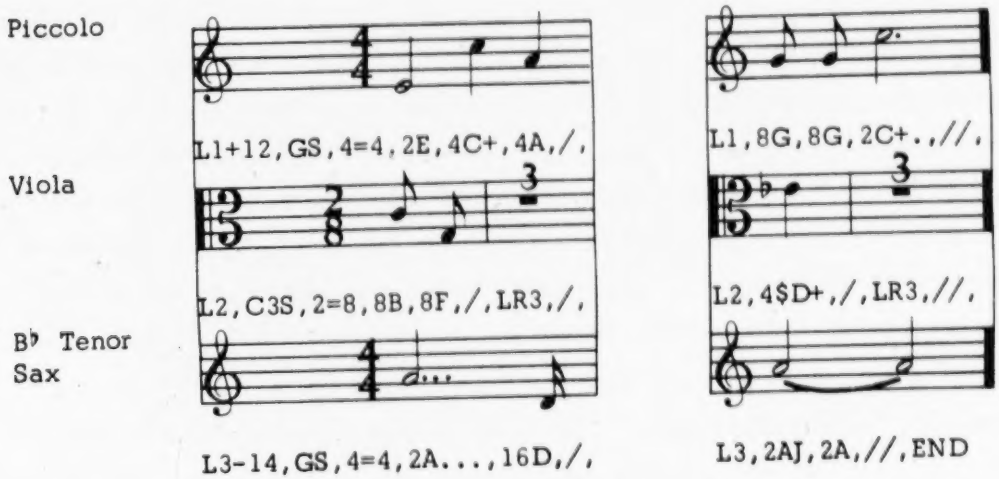
Multiple Staffs

Music which requires several instruments or voices is conventionally notated on different staffs, identified by position on the page and indication of the instrument or voice for which the staff is intended. For the character music notation such staffs are identified by number; thus all music notation following the occurrence of a staff number is considered to belong to that particular staff until a new staff is named. The normal character music notation for a staff identification number consists of L , followed by the number assigned to the staff, and a comma. At its first occurrence, the staff identification number must be followed by the clef signature, the key signature and the time signature.

An additional complication occurs because the notation for certain instruments

requires a transposition of the music. The character music notation for the staff identification number assigned to these instruments can be expanded to include the value of the transposition as follows: L , followed by the staff identification number, + indicating that the transposition raises the pitch or - indicating that the transposition lowers the pitch, the number of semitones required, and a comma. The transposition value desired must be given at the first occurrence of the staff number. After that, if no transposition value is given when the staff number reoccurs, the most recent value for this staff will be used.

The following diagram illustrates the use of multiple staffs with transposing instruments. In this diagram the music is read across the page but the character music notation is read first for the left hand side of the page and then for the right hand side of the page as would be done by the keypunch operator in preparing music one page at a time.



The keypunch data would actually appear as given in the following two lines.

```
L1+12,GS,4=4,2E,4C+,4A,/,L2,C3S,2=8,8B,8F,/,LR3,/,L3-14,GS,4=4,
2A...,16D,/,L1,8G,8G,2C+.,//,L2,4$D+,/,LR3,//,L3,2AJ,2A,//,END
```

Within the computer the data for each instrument is arranged in a single block to facilitate analysis.

Multiple Voices on a Single Staff

When multiple voices are present on a single staff, the problems in notation become far more complex because each note must be correctly assigned to the voice to which it properly belongs. The source of the complexity is that the symbolic music notation uses both vertical and horizontal arrangements of notes to determine which note is to be assigned to which voice, while any character music notation can only have a horizontal arrangement of data. Thus a two dimensional pattern must be collapsed into a single line of data in such a way that the computer can reconstruct the original two dimensional pattern.

A workable solution to this problem has been designed for the character music notation by requiring the use of certain rules in the preparation of such music. Some of these rules are based upon the nature of the symbolic music notation itself and therefore do not require any special justification. In addition to these it has been necessary to make a few arbitrary rules and a recommendation because of limitations within the current character music notation. The section of the computer's computational process which requires these additional rules has been designed so that it can be replaced by a more complex set of calculations requiring fewer rules.

The description of the character music notation will be given in terms of multiple voices. For music consisting of a single melodic line with occasional chords, the additional "voices" consist of occasional notes separated by lengthy rests. This description will be simplified by the use of the term "note cluster," where "A note cluster is a group of notes and rests on one staff which are performed with all of them beginning simultaneously." This definition does not require that they end simultaneously, but only that they begin simultaneously. Normally, a note cluster appears on a staff as a series of notes and rests arranged in a column which is perpendicular to the staff. In this column the notes may or may not be joined together by a vertical line.

The character music notation for note clusters is simple but highly significant; it consists of using Y in place of the usual comma as the character that separates the notes within the note cluster. Thus the character music notation GS,4CY4EY4G, indicates that the notes C, E, and G are performed

simultaneously, while the similar appearing character music notation GS,4C,4E,4G, indicates that a single voice is to perform the three notes C, E, and G sequentially. The simularity of these two notations means that the computer is extremely sensitive to errors involving the substitution of a Y for a comma and vice versa.

The convention has been established that the keypunch operator, in preparing the note clusters pertaining to the staff under consideration for the computer, reads them starting from the "lowest" of the notes and rests. The only exception to this is cases in which the voices cross. When this occurs the first note to be keypunched is the note to be performed by the "lowest" voice, the next note to be keypunched is the note to be performed by the "second lowest" voice, etc.

If voices cross from staff to staff, the character music notation must follow the voices so that each voice is kept on the staff number on which it began. Of course, if all voices on one staff shift into another staff, a change of clef signature can be made to simplify the preparation of the character music notation.

GS,4=4,4DY4FY4A,4A-Y4RY4A,4B-Y4EY4R,4CH+HY4GH+HY4EH+H,//,END

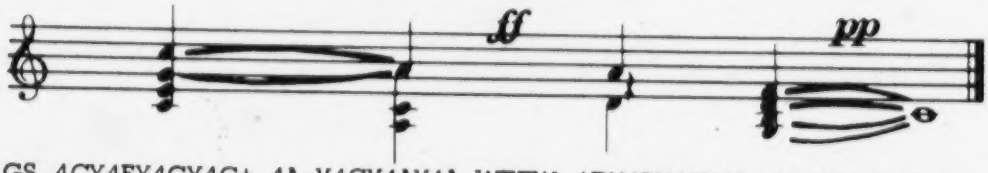
The above notational conventions alone are sufficient to handle music in which all note clusters contain the same total number of notes and rests. When this occurs, each note cluster contains only one note or rest for each voice and the computer has no problems in assigning notes and rests to the appropriate voices. The computer simply reads each note cluster, numbering the notes and rests in the order in which they occur. When all notes and rests for the cluster have been numbered, the computer renumbers them and assigns them to the various voices; finally it separates the voices to facilitate the musical analysis of each voice.

The basic problem is that since the current character music notation does not indicate slurs or the direction of the vertical line or flag on a note, the computer is unable to differentiate an upward from a downward vertical line or use this

information to recognize that a note with both lines is to be performed by two or more voices. Therefore, the computer has the problem of identifying notes or rests that appear once in the symbolic music notation but that must be performed by two or more voices.

For the computer this latter problem is solved in the confines of the current character music notation by the following arbitrary rule: If a single note is to be performed simultaneously by more than one voice, it must appear in the character music notation once for each voice using the note. Thus if a note is to be performed by two voices, the character music notation for the note must be repeated and if a note is to be performed by three voices, the character music notation for the note must be given three times. With regard to rests, a similar rule is as follows: If two or more voices become silent at a particular moment the character music notation of the note cluster must have a rest for each silent voice.

The following diagram illustrates the problems discussed above in that if a note (see the second and final note clusters) or a rest (see the third note cluster) appears only once in the normal symbolic music notation but must apply to more than one voice, the computer, and hence the keypunch operator, must be informed of this.



GS,4CY4EY4GY4C+,4A-Y4CY4AY4A,WFFW,4DY4RY4RY4A,4G-Y4B-Y4DY4F,
WPPW,1CY1CY1CY1C,//,END

The character music notation given below this diagram shows how the problem is solved for the computer; the keypunch operator must also know when a note or rest is to be repeated. The most practical solution to this problem is to require that a musician read the score and mark each note and rest which is used by more than one voice . A specific, arbitrary, and non-musical symbol for this purpose must be agreed upon by both the musician and the keypunch operator. The arbitrary symbol suggested here consists of an arrow appearing to the left of the note or rest which is to be duplicated and pointing directly toward the head of the note or the

center of the rest. The number of times the note or rest is to be duplicated is indicated by using multiple arrowheads with each arrowhead indicating one additional copy. Thus, if the note or rest is to be used by two voices, one arrowhead is used, while if five voices are to use the note or rest four arrowheads are used.

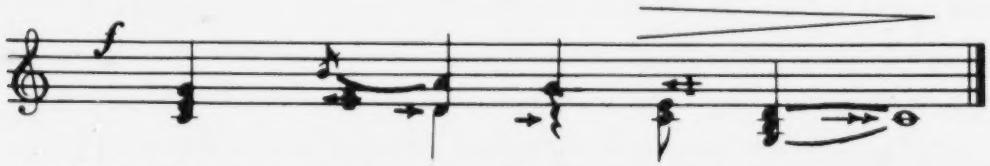
A second problem in the preparation of music with multiple voices is that rests are frequently left out of the original symbolic music notation because the horizontal position of a note alone is sufficient to determine when it is to be performed. This problem is also solved by requiring that a musician read the score and add the missing rests so that they can be included by the keypunch operator in preparing this music for the computer.

The final problem is that the only way in which grace notes can be assigned to their proper voice in the symbolic music notation is by their horizontal position on the page of music and by the slur line connecting each grace note to the note from which it obtains its time. The solution adopted consists of supplying some data for every voice in note clusters containing grace notes thus automatically assigning each grace note to the voice to which it belongs. Because there is no true data for the missing voice(s) an arbitrary character music notation consisting of a rest of time value zero, appearing in the character music notation as 0R [zero R], has been devised.

There must also be some method of indicating to the keypunch operator where these zero length rests are to appear in note clusters. The simplest method of handling this problem is, again, to have a musician read the score and place an arbitrary non-musical symbol at each point where the keypunch operator is to include a zero length rest. The arbitrary symbol suggested for this notation consists of an arrow placed to the right of the note cluster and aimed at the point between the two notes, two rests, or a note and a rest where the zero length rest is to be inserted. To indicate the number of zero length rests desired at any one point, the number is written near the tail of the arrow, thus minimizing possible confusion between these arrows and the arrows used to indicate that a note or rest is to be duplicated.

It is also recommended that for the computer each note cluster should contain data for every voice pertaining to the staff under consideration. The purpose of this is that if some data is given for each voice in every note cluster, the assignments

of notes to voices can be made within the computer simply by counting to determine the position of each note within the note cluster thereby eliminating many sources of errors. As can be seen all preceding diagrams illustrating multiple voices on a single staff satisfy this recommendation. Note clusters which do not have notes or rests for all voices normally do so because a preceding note or rest for the missing voices is still being performed at the time the current, incomplete note cluster is to begin. Because of this, there is again no true data which can be supplied for the missing voice(s) at this point; the arbitrary character music notation of a rest of time value zero is also to be used for this recommendation. The following diagram as marked for the keypunch operator includes examples of zero length rests and notes and rests used by more than one voice.



GS,WFW,4CY4EY4G,0RY0RY8SB,4DY4DY4A,4RY4RY4G.,WDBW,8CY8EY0R,
4G-Y4B-Y4D,1CY1CY1C,WDEW,//,END

In summary, the note clusters for multiple voices on a single staff are keypunched from the "lowest" voice to the "highest" voice using Y to connect the various notes of the note cluster and each voice must remain on the staff number on which it began.

The limitations of the current character music notation for the computer requires that: 1) if a note or rest is to be performed by two or more voices it must appear in the notation once for each voice that performs it, and, 2) note clusters containing grace notes must include sufficient zero length rests to specifically identify the voice to which each grace note belongs. This requires that a musician read the section of the score which has multiple voices on a single staff and add rests left out but implied by the position of the notes and rests present, indicate the zero length rests required by grace notes, and mark each note or rest which is to be repeated. It is also recommended that each note cluster be augmented by zero length rests as needed so that it contains information for every voice; this also

requires that a musician add zero length rests to note clusters which do not have data for every voice.

The plans for a revised character music notation will make it possible to use slur lines, the direction of the vertical lines or flags on notes and other information appearing in the symbolic music notation to eliminate all of the arbitrary requirements, symbols, and notational conventions given above as limitations caused by the current character music notation. While these additional requirements and the recommendation can then be ignored, the computer will, of course, also be able to handle music keypunched in accordance with them.

Additions

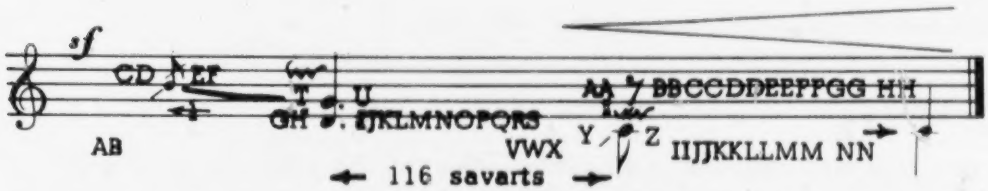
By use of the "Additions" defined here other materials may be included with music transcriptions and identified as such in the character music notation. These additions could include, for example: music symbols not discussed here; the text of the song; the part of speech of each word of the text; the accentuation expected of the text if spoken rather than sung; or combinations of these examples.

In the character music notation the method of indicating that an addition is to begin is to use the "prime" character ['] followed by the desired message. The end of the message is indicated by the occurrence of another prime character. Both primes must be present or the computer will attempt to interpret the message as being character music notation. Between these two prime characters, any character can occur except the prime character itself; for the computer, the length of the written message is currently limited to 28 characters, exclusive of the prime characters used to begin and end the message. The maximum length of message which the computer will save as an addition is currently limited to 16 characters. This permits the human to use a long message with plenty of spaces if desired, since the computer will condense the message by eliminating extra spaces and then will abbreviate it to save space. If a lengthy message is to be saved in the computer, it can be broken up into several short messages.

Additions can occur between note clusters, at the beginning of notes or rests, and at the end of notes or rests. If the addition occurs between note clusters, the second prime character is followed by a comma to separate the addition from the

next piece of data in the character music notation.

In the following example the convention has been adopted that the letters written to the left of a note or rest stand for an addition which appears at its beginning; letters written to the right of a note or rest stand for an addition which appears at its end; and letters written below the staff and between note clusters stand for an addition which appears between notes. In the character music notation all additions have been underlined for clarification.



GS,WSFW,'AB',0RY8S'CD'I+IB'EF',4'GH'D.'IJKLMNOPQRS'Y4'T'G.Z7'U',
'VWX',WCBW,8'Y'I+ICZ5*+(I=-116S)'Z'Y8'AA'R'BBCCDDEEFFGG''HH',
'IIJJKKLLMM','NN',4CY4C,WCEW,//,END

THE CARD FORMATS

With the description of the character music notation completed, all that remains is a discussion of the card formats used in preparing music for the computer. All cards used for an item contain a basic identification of the item in the first 10 columns of the card. The cards containing the character music notation have M in column 11 and a sequence number starting with 001 in columns 12 through 14. Columns 15 through 80 are used for the character music notation.

Additional data identifying the item can be given on one or more additional cards read previous to the cards containing the music. These cards are identified by a number between zero and six inclusive appearing in column 11 and contain identification data in columns 12 through 80.

The musical parameter data, when required, appears on cards which the computer reads after reading the identification cards and before reading the music notation cards. These parameter cards are identified by M in column 11 followed by zeros in columns 12 through 14. Columns 15 and 16 contain the sequence number

starting with 01 for these parameter cards and columns 17 through 80 contain the information on the parameters. The items which can be altered by parameters are: Accidentals, Time Signatures, Held Notes, Triplets, Micro-Accidentals, Estimated Pitch Modifications, and Bends and Dips. In addition to this the musician may also define Special Pitches by use of parameters; these special pitches are not affected by changes in the key signature. Full details on the parameters, the card formats used for parameters, and the uses of parameters along with a complete description of the card formats used for music and the identification of the item are given in Chapter Five of my Thesis.[2]

The description of the character music notation given above is limited but complete in that the musician can, if he wishes, prepare music for the computer using only the information given in this article. Data prepared for the computer using this notation will, it is expected, be completely acceptable to the computer using the planned revised and augmented character music notation. The revised notation will then, it is planned, be used as the foundation for a music analysis language capable of applying any objective musical analysis used in musicology or ethnomusicology to any music which has been written in a music notation based on the normal symbolic music notation.

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[2] "A Computational Method for the Analysis of Anglo-American Folksongs," 271 pp., MA (Folklore) Indiana University, September 1964. Chapters Two through Four of the Thesis contain a complete description of the character music notation utilizing the same titles and order of presentation of music symbols as this article. The notation was designed in 1962-3 and the first draft of the Thesis was completed in December 1963.

A MUSICAL INPUT LANGUAGE AND A SAMPLE PROGRAM FOR MUSICAL ANALYSIS[1]

Roland Jackson and Philip Bernzott

Computer analysis of music opens a new and exciting area to the scholar.[2] He can now look more deeply than ever before into the essence of a musical composition, perceive it in its many attributes, see its complex internal relationships--in short, come to a fuller awareness of style in the largest sense of the word. Obviously, so important a research tool can no longer be ignored by the serious musicologist. But to enter the world of computer technology the musicologist must gain some familiarity with the manner in which the computer operates, and detailed explanations--at least in the field of music--are still rare. The present study addresses itself to this need: by taking the initiate through a single computer project, step by step as it were, it hopefully will serve as a guide whereby he may in the future be better able to devise computer projects of his own. For now he will be expected to have some acquaintance with the basic principles of FORTRAN[3] and, if possible, access to a small-sized

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[1] The present article had its inception in a seminar called "The Application of Computers to Musical Analysis" offered at Roosevelt University during the summer and fall of 1965 and directed by Mr. Jackson. The sample program was initially devised by Mr. Bernzott, a participant in the seminar. Some of the results of the program, as applied to Berg's Lyric Suite, were described by Mr. Bernzott in a paper delivered at the fall meeting of the American Musicological Society in Chicago, November 14, 1965. For advice on certain particulars the writers would like to express their appreciation to Mr. H. Roy Marks of the Roosevelt University Computer Center.

[2] A number of different studies on this topic have appeared recently, among which might be mentioned: Walter Collins, "A New Tool for Musicology," Music and Letters XLVI (1965), 122-126; Richard Teitelbaum, "Intervallic Relations in Atonal Music," Journal of Music Theory, IX (1965), 72-127; and John Selleck and Roger Bakeman, "Procedures for the Analysis of Form: Two Computer Applications," Ibid., 281-293.

[3] The particular "dialect" of FORTRAN employed in the present study is described in FORTRAN: Programmed Instruction Course, International Business Machines Corporation, New York, 1961.

digital computer.[4]

The Two Essentials

To carry out any computer analysis the scholar must prepare two different types of information, the data and the program. Musically speaking, these might be described as:

(1) A musical input language which will translate musical symbols into numbers, letters, etc., intelligible to the computer.

(2) A program to direct the machine in a specific type of musical analysis.

The present study is divided into these two parts. The program, in this instance, is designed to analyze the frequency of individual chords within a given composition. We will now proceed to the musical input language.

A MUSICAL INPUT LANGUAGE

The input language we have devised is geared primarily for musical analysis; thus it is somewhat different from languages devised principally for the purpose of musical cataloguing.[5] For cataloguing, where the identification of themes has been the primary objective, use has been made of letter symbols, especially for pitches, and the data has been arranged in compact succession. Here, however, where the objective is analysis and entire musical compositions in all of their aspects must be coded, a basically numerical language has been used: pitches as well as rhythms are numerically conceived so as to lend themselves more immediately to mathematical routines. Also, to facilitate analysis these numerical symbols, although placed on cards, have been arranged so as to visually approximate the appearance of a musical score.

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[4] The computer used at Roosevelt University for this project was an IBM 1620.

[5] Of these should be mentioned: Barry Brook and Murray Gould, "Notating Music with Ordinary Typewriter Characters," Fontes Artis Musicae, XI (1964), 142-155; Lawrence Bernstein, "Data Processing and the Thematic Index," Ibid., 159-165; Barry Brook, "The Simplified PLAINE AND EASIE CODE SYSTEM for Notating Music: A Proposal for International Adoption," delivered at the Congress of the International Association of Music Libraries, Dijon, July 3, 1965 (we wish to thank Mr. Brook for putting a copy of this paper in our hands).

Apologia

An objection might be raised at this point that cards have already been made old-fashioned, if not obsolete, by more modern types of information storage. Where this is true, at universities with large computer centers at their disposal, cards can always be converted into tapes, disks, etc.--and indeed, the very input language here described can itself be converted into a new language whenever this may prove advantageous. At the same time it should be remembered that a number of scholars will for some time be bound to the use of smaller computers and will therefore be dependent on the use of cards. And finally, these smaller computers will be useful for experimental purposes while working out programs, thus saving valuable time on the larger machines.

The Number of Parts

As an initial step in coding, the scholar should scan the composition to be analyzed and determine its total number of sounding parts. This will offer no difficulty in, say, a five-part madrigal, but may take some deliberation in a free-voiced composition. As an example, Schoenberg's "Serenade" from Pierrot Lunaire will afford a total of ten different "parts," even though only three performers are actually playing:

01	Violoncello	
02	Violoncello	for occasional double and triple stops
03	Violoncello	
04	Sprechstimme	
05	Piano	for a maximum of six-note chords
06	Piano	
07	Piano	
08	Piano	
09	Piano	
10	Piano	

In this instance it actually turns out that parts 02, 03, 09, and 10 would be coded as rests throughout much of the composition.[6]

[6] Such a redundant aspect of the coding might be obviated by inserting trailer cards during the course of the data whenever the number of parts changes.

The Format of the Individual Card

col.	1 — musical data — 64	65 — identifications — 80

Columns 1 through 64 (or fewer as needed) offer a visual representation of a particular duration in time, such as a measure, beat, etc. This rhythmic "field" will be subdivided into a number of smaller fields of two columns each, and in these smaller fields the pitches, dynamic markings, timbre, etc. (each on separate cards) will be arranged according to their lengths. Columns 65 through 80 are reserved for identifications--a necessary precaution should a card become misplaced. Before describing the coding of actual musical data let us pause momentarily on these identifications.

Identifications * N.B., final page

col.	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
	2	2	4	0	4	P	1	0	4	3	1	9	2	1	A	S

65: "2" signifies a tie, i.e. that the pitch or rest will continue onto the next card (the measure, beat, etc.); "1" would indicate that it does not.

66, 67: the number of double columns (between col. 1 and 64) that were actually coded on this particular card.

68, 69: the number of the part (in this case referring to Sprechstimme).

70, 71: the type of analysis on this card. "P" stands for pitch, "D" would stand for dynamics, "A" for articulations, "T" for timbre, etc. Sometimes more than one card per type of analysis may be required; thus, "P1", "P2", etc.

72, 73, 74: the number of the measure.

75, 76: the number of the movement.

77, 78: the composition: in this case 21 stands for Opus 21, although PL (for Pierrot Lunaire) could just as well have been used.

79, 80: the composer's initials.

Rhythmic Durations

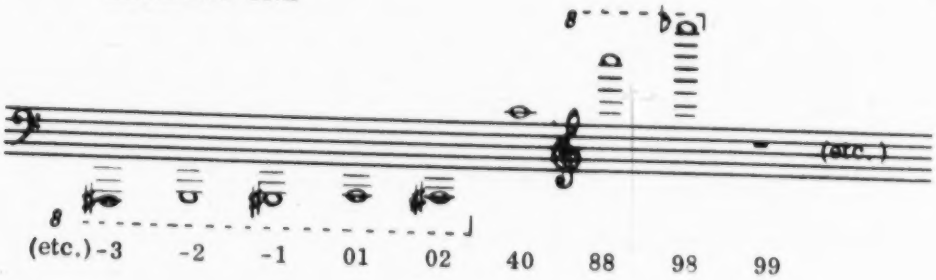
Now to the musical data itself (appearing in columns 1 through 64). Rhythm, as we have indicated, is never coded per se, but is measured in terms of the duration of other musical elements: the pitches, dynamic markings, etc. The basic unit of

rhythm will be the single double column, which is equated with the shortest time value occurring in a composition. If this time value were, say, a 32nd note, one double column would then represent a 32nd note, two double columns a 16th note, four an 8th note, etc. One measure of 4/4 time would take up 32 double (64 single) columns--the total amount allotted to musical information on any one card. It should be pointed out that the 64 columns may be divided in whatever manner seems most suitable for the composition at hand. And all 64 columns need not be used: two measures in 5/8 time with a 16th note as the shortest value, for example, would take up only 20 (of the 32 possible) double columns. Boulez's Marteau sans Maitre, with its frequent subdivisions of a single beat, might best be coded by allowing each beat to occupy 30 double columns. This would make possible a division of each beat into two, three, four, five, or six parts. Sometimes, however, an irregular rhythm might occur which could at best be notated somewhat freely--a procedure which, after all, does not really depart too much from an actual musical performance. Thus a septolet in this same composition, using 30 double columns, might be grouped in some such manner as 4-4-4-4-4-5-5.[7]

Pitches

Each pitch is assigned a unique two-digit number: 01 to 88 corresponds with the keys of a piano; 89 to 98 extends this range upwards; minus numbers extend it downwards. The number 99 is used to indicate a rest.[8]

DIAGRAM ONE



[7] Should this inexactness still prove objectionable to the analyst, however, he might, by exercising his ingenuity, devise a subdivision of the beat that would take care of all eventualities in a given composition.

[8] While "00" might seem more logical, it has not been used in order to avoid confusion between blank columns and 00 (the machine reads "bb" as "00").

This makes it possible to retain all the original pitches, should they be needed. At the same time a reduction to within a single octave--a desideratum in certain types of analysis (e.g., the program below)--can easily be achieved by a MOD function or some other means.

It will be noted that enharmonic equivalents are not distinguished: D♭' and C#' each equal 41. Should such a distinction prove desirable a second pitch card ("P2") might be used with two-digit symbols, "bD" or "bC"[9] occupying the same position as did the number on pitch-card one. One might also designate modifications from equal temperament in this way: plus or minus 01 to 99 cents (or simply b+ or b-) again assuming the same card position as does the basic pitch.

It should also be mentioned that all ornaments, such as trills, mordents, etc., should be realized as a succession of numeric pitches in the coding. This greatly facilitates their eventual analysis.

Finally it should be pointed out that any pitch or rest is considered to continue sounding through the ensuing double columns left blank, until a new symbol appears. Thus two half notes in a 4/4 measure with a 32nd note as the basic unit would be transcribed as a pitch symbol in columns 1 and 2 followed by another pitch symbol in columns 33 and 34; all other columns from 1 through 64 would be left blank.

Dynamic Markings and Other Information

Aside from the all-important "pitch-deck", other decks may (or may not) be assembled for such matters as dynamic markings ("D1", "D2", etc.), articulation signs ("A1", etc.), timbre ("T1", etc.), rhythmic nuances ("R1", etc.), and so on. Two-digit symbols, but of letter abbreviations rather than numbers, are again employed and the information placed in its appropriate rhythmic position. In this way comparisons may easily be made between any of them and a simultaneously occurring pitch. One may develop his own set of abbreviations;[10] some examples of our own follow:

---

[9] Here "b" signifies a blank column.

[10] The coder would do well to include a key to his abbreviations on separate cards: he might also list his "identifications" and such general matters about the composition as tempo markings and where changes of tempo occur.

FP	fp	PI	pizzicato
SF	sf	FE	fermata
MF	mf	LE	leggiero
1F	f	TE	tenuto
2F	ff	SP	Sprechstimme
3F	fff	ST	staccato

Sometimes the beginning (B) and ending (E) will need to be designated:

BC	beginning crescendo
EC	end crescendo
BS	begin slur
ES	end slur

An Example

The coding of one measure (m. 24) of Schoenberg's "Der kranke Mond" (Pierrot Lunaire)[11] should make clear the various points made above. Since in this case only one measure is coded the succession of cards is by part (01, 02, 03), by type of analysis (P1, D1, A1, A2, T1), and finally by measure (024); a more normal ordering would be by part, by measure, and then by type of analysis, with the rapidity of change in that order. The abbreviations used are defined above. (Diagram Two: see the following page.)

A SAMPLE PROGRAM

The following program is designed to analyze the chord-content of any harmonic composition and determine a "frequency-distribution curve" for the types of chords that occur in it. The frequency of each particular chord is considered in relation to the total duration of the composition. Thus, a major triad that is heard for a total of nine full measures of a twenty-measure composition would yield a time-duration of 45 percent.

The analysis of the chords--and every vertical structure is taken into account--is accomplished in the following manner: 1) the pitches that are, at any given point, sounding simultaneously will be reduced to within a single octave, 2) the distance between the lowest sounding pitch and the other pitches will be measured intervallically, 3) the intervals thus obtained will be used to build a chord in

[11] As published in Universal Edition.

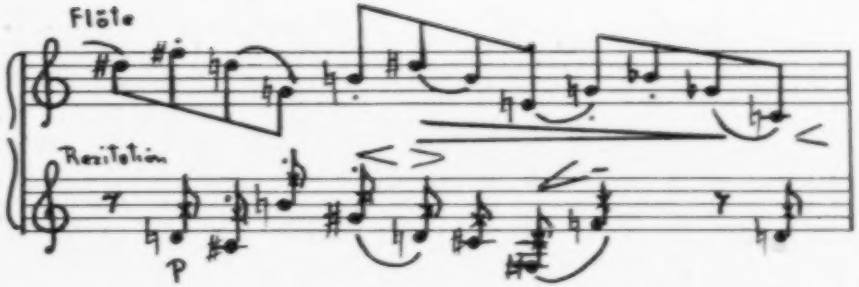
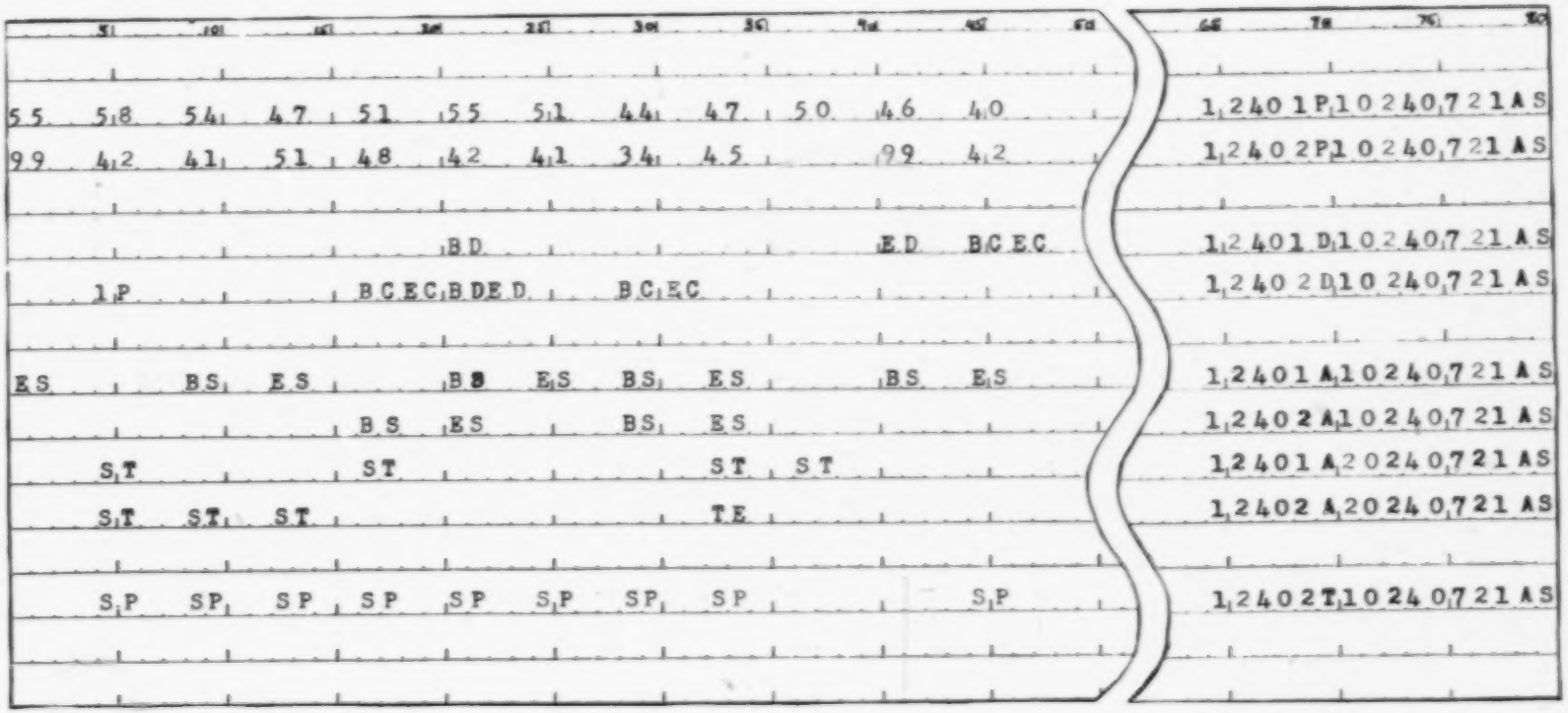

Flöte
Rezitation
p

DIAGRAM TWO


55 5,8 54, 47 51 55 51 44, 47 50 46 40 1,2401P,10240,721AS
99 4,2 41, 51 48 42 41 34, 45 99 42 1,2402P10240,721AS
BD ED BCEC 1,2401D,10240,721AS
1,P BCEC,BDED BC,EC 1,2402D10240,721AS
ES BS, ES BS ES BS, ES BS ES 1,2401A,10240,721AS
BS ES BS, ES 1,2402A,10240,721AS
S,T ST ST ST 1,2401A,20240,721AS
S,T ST, ST TE 1,2402A,20240,721AS
S,P SP, SP SP SP S,P SP, SP S,P 1,2402T,10240,721AS

decimal notation, 4) the chord in this form will be compared with the chords in a Chord Table, which includes all the possible twelve-note combinations, and 5) after the chord has been identified in this way and its inversion determined, this information goes into output for a final statistical evaluation.

The Chord Table

1. .000000000000
2. .100000000000
3. .110000000000
4. .101000000000
5. .100100000000
6. .100010000000
7. .100001000000
8. .100000100000
9. .111000000000
10. .110100000000
11. .110010000000
12. .110001000000

We have just illustrated the first twelve "chords" in a Chord Table which, when completed, would consist of 352 such chords. This would take into account all the possible combinations of from one to twelve tones, excluding, however, all transpositions, (Rameau) inversions, and octave doublings. To represent the chords, and to put them into a computable form, a twelve-digit decimal symbolism has been devised, wherein the twelve positions to the right of a decimal point represent the twelve different pitches within an octave. A "1" in any of these twelve locations indicates the presence of a tone, a "0" its absence (e.g., a major triad: .100010010000). All chords have been arranged so as to begin with ".1", which symbolizes the lowest pitch, while each succeeding position to the right represents succeeding semitones within an octave. This intervallic notation is in some respects comparable to the old figured-bass notation, where chords were also conceived in terms of intervals above the lowest sounding pitch, except that here chords are classified as being in "root position" (the form of the chord appearing in the Table) or in an inversion. When the chords have no relation with tertian harmony, however, assigning one chord form to root position, another to an inversion, may seem rather

arbitrary. But it should be made clear that the "root positions" of the chord table by no means constitute an absolute (they may, in fact, freely be changed by the analyst); rather they are simply a convenient reference against which other forms of the same chord may be measured.

Specification Statements, Clearance, Reading the Chord Table

```
FANDK 1304
DIMENSION CHORDS(70), NOUT(70,4), INSTR(NUMBER,32)
NUMBER=____(to be filled in with the number of parts)
```

These opening statements are concerned with reserving sufficient space in the computer to carry out the particular program that is to follow. FANDK 1304 (read F AND K 13 04) indicates the length of the longest floating-point (F) number, i.e. 13 significant places to the right of the decimal point, and of the longest fixed-point (K) number, i.e. 04 digits long. The DIMENSION statement sets aside enough space in the computer's memory for each of the three variables: CHORDS, referring to the Chord Table just described--but only its first 70 items, that is chords containing 0 to 4 different tones, which will be processed during this part of the program (due to the possibility of limited computer memory, chords that contain more notes will be dealt with later); NOUT, referring to the final output, where we will wish to draw upon these 70 chords along with their 4 possible positions (root position and three possible inversions); INSTR, referring to the actual coded pitches, which is a two-dimensional list indexing the total number of parts (i.e. NUMBER) as well as the total number of double columns (i.e. 1 to 32) to be read on a single card (one card for each part)--here once again because of the possibility of limited space, the parts will be read and stored for only one card-duration at a time.

```
      DO  1 L=1,70
      DO  1 M=1,4
1     NOUT(L,M)=0
```

These statements will clear the output area, that is insure that its entire contents will be equal to zero before the program is actually begun. The variable L indexes the output chord-numbers, while the variable M indexes the number of possible inversions (including root position). Statement 1 sets NOUT (i.e. the counter for each location in the output area) equal to "0".

```
      DO 2 N=1,70
2     READ 3, CHORDS(N)
3     FORMAT(F13.12)
```

At this point the first 70 chords of the chord table are read into memory according to the FORMAT cited: the chords will occupy 13 columns and consist of a decimal point followed by 12 digits. The variable N indexes these chords; while statement 2 instructs the machine to fill the space reserved for the chord table with information read from 70 cards.

Reading a Single Card Per Part

Since, as we have been mentioning, the present program is planned in such a way that it may be used on the smallest computers (as well as larger ones) only a single card for each of the parts, containing a maximum of 32 smallest time-durations (that is 32 double columns), will be read into the machine at one time for processing. The remainder of the piece will be read similarly after the present information has been processed.

```
4     DO 5 J=1,NUMBER
5     READ 6, (INSTR(J,K), K=1,32),NO
6     FORMAT(32I2,1X,I2)
```

Here J indexes the number of parts, while K indexes the 32 double-column fields (these two variables, J and K, always retain the same significance throughout the remainder of the program). The variable NO is introduced to stand for the number of double-column fields actually coded on a card--since the actual number of such fields may vary from one card to the next. Finally, the FORMAT specifies where on the individual card the required variables are located: 32 fixed-point double-column fields, followed by one column to be ignored (this is the "tie-column" described in the coding ~~method~~ above), followed by a two-column fixed-point field containing the value for NO.

```
IF(INSTR(1,1)7,100,7
```

This provides a check to see if the end of the composition has been reached. A few blank cards (enough to read NUMBER of parts) are always inserted at the end of the pitch-deck so that as soon as blanks, read by the machine as "00", appear in the first double-column field--in the pitch deck this first double column always had to

contain some number, representing either a pitch or a rest--the IF statement sends the computer to statement 100, thereby ending the computation. Otherwise the program will proceed to the following set of statements:

```
7     DO 9 J=1, NUMBER
      DO 9 K=2, NO
      IF(INSTR(J,K)9,8,9
8     INSTR(J,K)=INSTR(J,K-1)
9     CONTINUE
```

The purpose of these statements is to fill in pitches or rests for every double-column duration that was left blank when the cards were originally coded. Blank spaces, you will recall, meant that the previously coded pitch or rest was to be sustained. E.g.:

(part 01)

99				40		
28						32

etc.

The IF statement tests whether or not blank columns, actually read by the machine as "00", are occurring in the part and time-duration being tested. If so, these blank columns will be replaced by whatever pitch or rest preceded them. E.g.:

(part 01)

99	99	99	99	40	40	40
28	28	28	28	28	28	32

This permits the testing of each vertical sonority as it occurs in succession.

The following statement then initiates the principal DO loop in the analysis:

```
DO 50 K=1,NO
```

It should be pointed out that all subsequent uses of K (as in the subscript "J,K", for instance) refer always to its value as determined by this particular DO statement. In other words, K always tells us which double column of time-duration is currently being tested. Only one double column at a time, between 1 and NO (the number of double columns on the particular card), will be harmonically analyzed during each cycle of this DO loop.

Finding the Lowest Tone and Reducing the Pitches to Within a Single Octave

```
      LOWEST=INSTR(1,K)
      DO 11 J=2, NUMBER
      IF(INSTR(J,K)-LOWEST)10,11,11
10    LOWEST=INSTR(J,K)
11    CONTINUE
```

These particular statements are designed to discover the lowest pitch in a given sonority, this pitch to be represented by the variable LOWEST. Assuming, to begin with, that LOWEST is to be found in part 1, each of the other parts, 2 through NUMBER (as indexed by J), are then compared successively with the assumed lowest pitch; and should any be found to have a lower pitch, statement 10 replaces the assumed value of LOWEST with this new, lower, value. After each part has been tested the program then moves to the following set of statements:

```
      IF(LOWEST-99)13, 12, 13
12    N=1
      LOC=1
      GO TO 40
```

This provides a "rest-check." The IF statement tests whether the lowest tone is a rest, i.e. 99 in the coding. If it is, this means, in effect, that all the parts in this particular time duration would also have to be rests (since none would be lower than "99"). And since there is no need to build a chord consisting exclusively of rests, considerable computer-effort will be saved by sending the program directly to statement 40, where this duration will be counted, as a rest, in output before going back to process the next Kth duration. (The meaning of N and LOC will become clear later on in the program.) If, however, the lowest part turns out not to be a rest, we then move to:

```
13    IF(LOWEST)14, 17, 17
14    DO 16 J=1, NUMBER
      IF(INSTR(J, K))15, 16, 16
15    INSTR(J, K)=INSTR(J, K)+1
16    CONTINUE
```

This surmounts a slight difficulty arising whenever the lowest tone, as well as any other tone, turns out to be less than "01". To arrive at the correct intervallic distance between the minus numbers representing these tones (see the input language described above) and the "plus" numbers that may occur above them, one needs to add one to each minus number. For example, -4 to 04, a perfect fifth from FFF to CC, should be equivalent to 09 to 16, the same perfect fifth from FF to C. But instead of a distance of "7", as in the latter, a subtraction would produce the number "8". Therefore, to remedy this, statement 15 adds a one to any pitch, INSTR (J, K), that happens to be less than zero. When this is accomplished we then proceed

to:

```
17    DO 21 J=1,NUMBER
      IF(INSTR(J,K)-99)18,21,18
18    INSTR(J,K)=INSTR(J,K)-LOWEST+1
19    IF(INSTR(J,K)-12)21,21,20
20    INSTR(J,K)=INSTR(J,K)-12
      GO TO 19
21    CONTINUE
```

which reduces all the pitches to within one octave of the lowest tone. First, however, each part (as indexed by J) is now tested individually by the first IF statement to find out whether or not it is a rest, 99. Only if it is not does the program proceed to statement 18, where the lowest tone is subtracted from the pitch value of the part. This will transform the value of the part from an absolute pitch to an intervallic distance from the lowest tone (a most important operation for the rest of the program to follow). But one is always added to this distance so that a unison will have a value of one rather than of zero (and the perfect fifth mentioned a ways back would actually turn out now to have a value of "8" rather than the "7" we implied it would have at that time). The reason for this is that DO 24, below, cannot be indexed 0, 11. Statement 19 tests the results of the preceding operation to determine whether or not the intervallic distance is within one octave of the lowest tone. If it is not, statement 20 reduces the interval successively by 12 until it eventually comes within the octave (if a MOD function were available it might be used instead at this point).

Building the Chord in Decimal Notation

In the following statements chord (S) is gradually constructed above the lowest tone according to its intervallic content. The chord is represented (as in the Chord Table) in a decimal notation consisting of twelve digits placed to the right of a decimal point. To begin, the symbol for the chord that is being built (i. e. S) and the symbol representing the number of different pitches it contains (i. e. KOUNT) are each set equal to zero:

```
S=.000000000000
KOUNT=0
```

Next, in two nested DO loops INTERV indexes in succession each of the twelve possible intervals within an octave, while J indexes each of the sounding parts:

```
      DO 24 INTERV=1, 12
      DO 22 J=1, NUMBER
```

Then an IF statement compares each of the twelve intervals (INTERV) with each of the sounding parts (J) in whatever time-duration is being tested (K). Whenever it is found that a given part produces an interval above the lowest tone the program is sent to statement 23. Otherwise the DO loops are recycled through statements 22 and 24:

```
      IF(INSTR(J, K)-INTERV)22, 23, 22
22    CONTINUE
      GO TO 24
23    S=S+1. E-INTERV
      KOUNT=KOUNT+1
24    CONTINUE
```

Statement 23 adds to the chord (S) a "1" in the place to the right of the decimal point corresponding to INTERV. For example, if the intervals above the bass note (the bass note is always represented by number 1) consist of a major third (represented by number 5) and a perfect fifth (represented by number 8) statement 23 would successively build the chord as follows:

```
.000000000000
.100000000000
.100010000000
.100010010000
```

And each time a "1" is added KOUNT will be incremented by one, since this means that a different pitch-class will have been found. Here it should also be noted that two of the same kind of interval will never be recorded since the IF statement sends the program immediately to statement 23 as soon as the first of any particular kind of interval is found.

Deferring Chords of Five Notes or More and Dividing Up the Chord Table

```
      IF(KOUNT-5)27, 25, 25
25    PUNCH 26, S, KOUNT
26    FORMAT(F13. 12, 2X, I2)
      GO TO 50
```

At this juncture the program determines whether or not five or more notes are present in the chord (limited storage space may only permit a maximum of four-note chords to be processed during this part of the program, it will be recalled). Should

there be five or more notes the IF statement sends the program to statement 25, where the chord (S) and its number of notes (KOUNT) will be punched for future processing, according to the given FORMAT: thirteen spaces, twelve to the right of the decimal point, for the chord itself, two blank spaces, and the number of notes in the chord. Then the program is sent to 50 to begin processing the next time duration (K). If, on the other hand, there are less than five notes, the program then proceeds to the following:

```
27    IF(KOUNT-3)28,29,30
28    L=2
      M=8
      GO TO 31
29    L=9
      M=27
      GO TO 31
30    L=28
      M=70
```

These statements set limits--L and M--to three different groups of chords in order to facilitate reference to them in the chord table: group one (chords 2 to 8) is comprised of 1 and 2-note chords (i. e. single notes and intervals), group two (chords 9 to 27) of 3-note chords, and group three (chords 28-70) of 4-note chords. The IF statement assigns a chord to one group or another.

Identifying the Chord (in the Chord Table) and Finding Its Inversion

```
31    INVERT=O
32    DO 33 N=L,M
      IF(S-CHORDS(N))33,37,33
33    CONTINUE
```

In this part of the program a comparison is made between the present chord (represented by S) and the chords listed in the chord table (i. e. N). The comparison takes place in the IF statement, which sends the program to statement 37 as soon as S is found to be equivalent to one of the chords in CHORDS (N)--i. e. as soon as a subtraction between them results in zero. It should be added that INVERT (a variable that provides a record of how many times one must invert the chord before it is in root position, as this is defined in the chord table) will remain at "O" if a correspondence is found immediately: in effect, this will indicate that the chord is in "root position". If, however, no correspondence should be found after all the chords

in N have been tried, the program will then automatically proceed to the following set of statements, whose purpose it will be to discover what position chord (S) is actually in:

```
34    S=S*10.0-1.0+1.E-12
      INVERT=INVERT+1
      IF(INVERT-KOUNT)35,25,25
35    ITEST=S*10.0
      IF(ITEST-1)36,32,32
36    S=S*10.0
      GO TO 35
```

Here chord (S) is, in effect, inverted until it is found to match some chord in the chord table (i.e. until it is in root position as defined by the chord table). Statement 34 begins a process of "rotating" the chord clockwise digit by digit. This is accomplished (1) by multiplying it by 10. so that ".1" will move over to become "1." and all other digits will move accordingly one position to the left, (2) by subtracting one, thus, in effect, leaving "0." to the left of the decimal, and (3) by adding ten to the -12th power so that a "1" will now be put into the twelfth place after the decimal point. Whenever a "1" is so rotated from first to twelfth position the chord is inverted one time: thus INVERT=INVERT+1. E.g.:

(original form of a 6/4 chord)	.100001000100
(multiplied by 10.)	1.00001000100
(subtract the 1)	0.00001000100
(add ten to the -12th)	.000010001001

After a rotation, however, a "0" might appear in the first position to the right of the decimal (as in the example above). To avoid comparing the chord in this form with the table (where all the chords begin ".1") statements 35 and 36 continue to cycle the chord until it again begins with ".1". Statement 35 moves all digits one place to the left and then only reads the first digit (truncating the others since ITEST is fixed point). The following IF statement tests whether this digit is a "1" or a "0", and as soon as it is "1" the chord is sent back to statement 32 to be compared with the chord table once more. Eventually a match should be found with the chord table, whereupon the program is sent to the next set of statements. (However, if a match is not found after the chord has been inverted as many times as it contains notes, it will then have returned to its original position, having exhausted all possibilities. An escape is provided for this eventuality by the IF statement following statement 34, which

sends the program to statement 25, where the "unmatched" chord will be punched for later reference.)

```
37    IF(INVERT)38,38,39
38    LOC=1
      GO TO 40
39    INVERS=KOUNT-INVERT
      LOC=INVERS+1
40    NOUT(N,LOC)=NOUT(N,LOC)+1
50    CONTINUE
      GO TO 4
```

The main purpose of these statements is to transfer the information found in INVERT into a new variable INVERS. Whereas INVERT had indicated how often chord (S) had to be inverted to match its prototype, INVERS defines the opposite, telling us how often the chord in the chord table would have to be inverted in order to match chord (S)--INVERS, then, tells us the actual inversion of the chord. Example: a triad in 6/4 position would result in an INVERT of one but in an INVERS of two. Which is to say that the sum of INVERT + INVERS, except for root position, will always be equal to the number of notes in the chord, i.e. KOUNT. Thus, when KOUNT=4:

INVERT	INVERS	LOC
0	0	1
1	3	4
2	2	3
3	1	2

There remains to be explained LOC. This defines the column, or LOCation, in output in which the information concerning the inversion will be placed. One is always added to INVERS for this purpose. Thus a root position chord will be placed in the first location, a first inversion chord in the second location, etc. The statements themselves should be fairly clear: 37 sends the program to 38 if INVERT is "0", whereupon LOC becomes "1". Otherwise it is sent to 39, where INVERS is arrived at by subtracting INVERT from the number of notes in the chord (KOUNT). Statement 40 increments the output location by one; N indexes the number of the chord (in the table), LOC the chord's inversion. Statement 50 then recycles DO 50, whereby the following Kth duration will be processed, and GO TO 4 instructs the machine to read the following set of cards as soon as DO 50 has completed the present set.

Punching the Output Data

After the entire movement or composition has been analyzed by the above method the following statements will then punch the output (NOUT) on cards--one card for each chord that occurs.

```
100  DO 13 N=1,70
101  PUNCH 102, N, (NOUT(N, LOC), LOC=1,4)
102  FORMAT(I4,4(2XI4))
     CALL EXIT
     END
```

In NOUT, then, we will find the chord number (N) as well as the LOCation of the inversion (1 to 4). Statement 102 describes the manner in which this information will be reproduced: four columns for the chord number, two blank columns, four columns for a chord in root position (i.e. LOC 1), two blank columns, four columns for a chord in first inversion (LOC 2), etc. CALL EXIT and END formally end the computation.

The Program for Chords of More Than Four Notes

Essentially the same program should be run through two more times, once for chords of 5, 6, and 7 notes, and once for chords of 8, 9, 10, 11, and 12 notes. Since the first program has already "built" the chords, statements 5 to 25 (where this "building" occurs) are omitted. In this abbreviated form the program will process only one chord at a time. Therefore, statement 4 becomes READ 5, S, KOUNT, and statement 50 is replaced by GO TO 4. Otherwise only certain details need to be altered, most of these having to do with the number of chords. Thus, for 5, 6, and 7-note chords: DIMENSION CHORDS (212), NOUT(212, 7); and for 8, 9, 10, 11, and 12-note chords: DIMENSION CHORDS (70), NOUT (70, 11). Likewise, different limits for L and M would have to be set for reference to the chord table.

Determining the Percentages of the Chords

```
     DIMENSION LOC(11)
1    FORMAT(4H, 11(2XI4), F6.2, I4)
2    READ 1, (LOC(J), J=1, 11)
     ISUM=0
     DO 3 J=1, 11
```

```
3     ISUM=ISUM+LOC(J)
      SUM=ISUM
      PERCNT=SUM*100./_____(to be filled in with
                           the total number of
                           smallest time-dura-
                           tions in the movement
                           being analyzed)
      PUNCH 1,(LOC(J),J=1,11),PERCNT,ISUM
      GO TO 2
      END
```

Here ISUM totals the number of times each particular kind of chord occurs, irrespective of its inversions (i.e. root position and inversions considered as one entity). PERCNT calculates what percentage of the total time-duration in the composition was devoted to this particular chord. The result will then be punched out according to the FORMAT: four columns for the chord number (4H), 66 columns, i.e. eleven 4-column fields, each one separated by two blanks, for the maximum possible inversions (11(2XI4)), six columns for a decimal percentage, i.e. two blanks and 00.00 (F6.2), and four columns for ISUM (I4). The entire process just described is applied successively to each chord in the chord table.

In Conclusion

It is hoped that the program we have just described will point the way towards a number of future projects. One might choose to follow it, for example, with a program designed to study the frequency of chordal successions (such as how often a major triad is followed by a particular kind of seventh chord), then the frequency of actual chordal progressions (which would take into consideration root movements), and eventually modulations, the use of key-areas, etc. This combined with still other contributions to computer analysis will bring us closer to what might be described as a "style profile" of a given musical composition--an invaluable aid in all future stylistic analyses and comparisons.

Finally, a proposal: would it not be useful for musical scholars to collaborate on a library of coded music? Such a library, easily duplicated in card or other form, could be distributed on an exchange basis.[12] Differences in coding methods might be

[12] It might be mentioned that a coded library of this kind has already been begun at Roosevelt University with examples of compositions by Schoenberg, Berg, Webern, Hindemith, Bartok, and Boulez.

surmounted by developing conversion programs to translate one input language into another. This kind of exchange would immediately make possible a stylistic comparison between individual musical compositions and ultimately, it is hoped, between large historical periods.

* *Identifications*

N. B. Upon further consideration the authors feel that one aspect of these identifications (see above) might better be modified: column 65 may now be omitted altogether (perhaps some other item of information could be inserted here later), and whenever a tied note or continuing rest occurs across a bar-line the following card will be left blank in its opening double columns for as many spaces as are necessary before a new note is attacked.

AN ESSAY TOWARD SPECIFICATION OF A MUSIC-READING MACHINE[1]

Michael Kassler

Abstract. A description is given of an hypothesized optical character-recognition machine that can recognize and discriminate amongst the primitive symbols and formulas of current common musical notation. The description is essentially a specification of an effective procedure whereby, given any musical composition as input, a sequence of binary digits that uniquely represents the composition is output.

FOREWORD

This essay contains a description of an hypothesized optical character-recognition machine M that is able to recognize and discriminate amongst the primitive symbols and formulas of current common musical notation (CCMN). The description of M is given at a level 'above' the levels of primitive circuitry and microprogramming: we do not mention henceforth flying-spot scanners or map-matching or autocorrelation techniques, but treat M rather as a 'black box' that, given a particular composition in CCMN as input, produces a certain sequence of binary digits (i.e., '0"s and '1"s) as output. The input to M can be assumed to be ordinary 35 mm. microfilm (this will avoid the page-transport problem and also should allow

[1] Research in connection with the writing of this article was partially supported by the National Science Foundation, through Institutional Grant No. C-248 to Princeton University. The author acknowledges gratefully the advice concerning and assistance with this article offered by Professors Lewis Lockwood, E.J. McCluskey, Jr., and Arthur Mendel.

the 'reading' of numerous music microfilms now in existence). The output from M, if not entered directly into an 'on-line' computer memory, can be assumed to be in any computer-acceptable form--e.g., magnetic or punched-paper tape.

'CCMN', like the English names of other natural languages, strictly does not denote a particular language but rather varies over several languages which became different one from another by design or evolution. The CCMN used by Schoenberg differs in some particulars from the CCMN used by Schubert, which differs in some particulars from the CCMN used by Schütz: and even so straight-forward a change as the substitution by John Heptinstall of round-shaped for lozenge-shaped note-heads[(1)] [2] is of course a change of primitive symbols and hence a change of language.[3] Since it is desirable that our machine M 'read' as many 'dialects' of CCMN as practical, we shall attempt to describe CCMN 'panchronically', i.e., to describe the 'union' of many of these 'dialects'. It is anticipated that the 'dialects' of CCMN most often encountered by an actual machine would be those employed in the last 150 years of music publishing, and these in any case would be the most important 'dialects' for initially projected research.

Ultimately we should like to be able to have 'read' automatically all sorts of music in CCMN: printed music, music handwritten in pen or pencil, etc. However, only the ability to 'read' printed music is specified of M.[4] For purposes of machine design, a thorough study of various methods of printing music may be required to characterize with the necessary precision the properties of particular printed instances of each CCMN primitive symbol and some collections of such symbols.

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[2] See the list of references which concludes this report.

[3] Alternatively, it could be claimed that the change was one not of primitive symbols but of printing fount for the same symbols, as lozenge-shaped and round-shaped note-heads do not (ordinarily) occur in the same composition. This latter fact may be useful in reducing the number of entries searched from the 'alphabet' of characters stored internally in M. (This aspect of Heptinstall's work was anticipated by the French printer Etienne Briard.)

[4] Although music manuscripts written professionally may be not much more difficult to 'read' automatically than engraved printed music.

Such a study, to our knowledge, has not been made.[5] There are published bibliographies of the literature on music-printing(2), (3), and some of this literature may be quite useful for that study.[6]

Ultimately also we should like to have 'read' automatically various musical notations other than CCMN. But the amount of printed music in CCMN--including music already transcribed from other notations--is sufficiently great that the need for machines to 'read' those other notations is not urgent.

If the machine M can be realized in such a way that, without a great increase of cost, alphabetic characters from many founts can be 'read' automatically, then this capability should be included to allow text (if any) to be recognized together with the affected notes. Otherwise, text-'reading' capability can be deferred or left for another machine.

Much as the recent development of machines for the production of precisely-specified sound coincided remarkably with the design or evolution of music-compositional systems 'demanding' the availability of such sound(11), the new character-recognition technology(12), (13), (14), (15), (16) coincides, also remarkably, with

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[5] Foss (4) has compared with respect to two short musical examples several English music-printing founts. His discussion is not technical, but the following comment from his p. 101 seems worth quoting here. 'The problem of printing music in a distinguished manner lies...also in the fact that there is so limited a choice [of types]. The typographer may choose for his book a type suitable for the matter of it, but that is almost out of the question for the musician, who must use the one style his printer possesses for old and new music, for hymns and rag-time, for twelve-stave and one-stave music.'

Foss (5) adds (in footnotes on p. 295): 'Though I refer to a "style", I recognize that there are actually several founts available. But they are all so similar to the eye that the differences are negligible and could hardly be observed by the most expert inquiry.' '...the variations in the proprietary founts are so minute as not to be worth the attention of anyone whose interest is practical and not academic.' The first of these last quotations refers to letter-press type; the second, to engravers' punches.

The firm of Breitkopf and Härtel prepared, in 1885, an illustrated listing (39) of their various music-printing capabilities (including engraving, autography, and typography).

[6] For introductory articles on music-printing, see Foss (6) and Gray (7) and Meyer and O'Meara (8). A more detailed exposition is presented in Gamble (9). There are also articles about particular music printers, e.g., Audin (10).

recent developments in musicological standards[7] that appear to require the fruits of this technology for the bringing of musical data into a form suitable for interrogation, manipulation, and conversion, at practical speeds. Our presentation here of a machine so hypothetical as M should be construed not as a suggestion that M's realization is outside the scope of this technology but as our endeavor to assist the making of an actual machine by specifying some requirements that, up to isomorphism, it will have to fulfill.

* * *

The character-recognition machine M is assumed to scan a composition in CCMN just once. The direction of the scan on each page is from left to right, one staff at a time, starting with the top staff and proceeding one staff at a time to the bottom staff, and then going on to the next page. (The staff in CCMN consists always of five parallel straight lines, to which are added when necessary up to nine upper and nine lower ledger lines: there are thus 45 possible staff-positions.[8]) It will be assumed that neighboring staffs on the same page never 'interfere' with each other, i.e., that the staff to which a note, rest, phrase-mark, etc. belongs can be determined automatically.

A segment of a single staff will be called a 'scanning unit' if 'every' hypothetical line perpendicular to the staff lines that can be drawn through them throughout the segment intersects at least one CCMN symbol other than a staff line, a phrase-mark, a bracket, text, a part of a crescendo or decrescendo sign other than the vertex or the opposite end, or a beam connecting two or more eighth-notes or notes of smaller note-durational value. In the following example, the scanning units are pointed out

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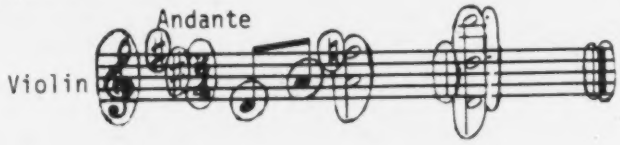
[7] (17) is an excellent sample of current musicological research; for an 'American' sample, see the Journal of the American Musicological Society, 1948 and continuing.

[8] For a typical primer on many aspects of CCMN, see (18). The present essay is not such a primer, and some familiar terms naming properties of CCMN are used here without introductory explanation.

by their approximate encirclement.



If a scanning unit contains more than one CCMN symbol (other than the symbols mentioned in the preceding paragraph) then the machine M must output information corresponding to each of these symbols. The order in which this information is output does not matter so long as the order is invariant from one scanning unit to the next: for example, given the scanning unit

the machine could notify (assuming that the above segment is affected by the treble clef) the F, the upper D, the A, the lower D (in that order), or the upper D, the lower D, the F, and the A (in that order), depending on the ordering principle adopted for the outputting of information about the contents of scanning units.

CCMN, as a system, can be formulated in several different ways.[9] Implicit in what follows is a formulation which treats--for example, in the case of notes--staff-position, stem direction, and 'note-duration' as attributes of a note, and a note (composed of these attributes) as a primitive symbol in the sense that a particular output word will be emitted ordinarily from M when a particular note (but not merely a particular staff-position, a particular stem direction, or a particular 'note-duration') is scanned. This formulation, it is hoped, does not restrict the

[9] Some of these formulations have actually been applied in music printing (8), (9), (19), (20). The extent to which it is desirable for M to simulate inversely the process used to print the composition being 'read' by M is not known. E.g., there are founts for the printing of CCMN in which each primitive (i.e., indivisible) element for the representation of pitch consists of a note together with staff lines (so that the note is on a particular staff-position). And there are other founts essentially containing the staff as one primitive element and the notes (without staff lines) as others. We do not know whether it would be better to use the same or different recognition logics when 'reading' from the two sorts of founts.

construction of a realization of M too severely. (Of course, a mere 'facsimile' machine, that outputs a (0, 1)-matrix whose $(i, j)^{\underline{th}}$ entry is 1 if and only if a corresponding square on the input page is black, will not realize M.) The 'note-duration' of a scanned note could be determined by matching the scanning unit containing that note against sufficiently many stored samples or by masking the staff lines out and comparing the shape of the resultant note-head, stem (if any), and tail (if any) against a smaller number of stored samples.[10]

Each of the 45 staff-positions will be named by the sequence of six binary digits that is indicated in the following diagram by placement on the staff-position of that pair of Arabic numerals whose denotation in the octal system is the same as that of the six digits in the binary system.

[10] The problem is somewhat more complex if the scanning unit contains more than one note, as different notes may share the same stem and tail (if any). It should be unnecessary to store samples of every possible combination of notes if the recognition logic can match scanned shapes against not only stored samples but also the 'union' of certain stored samples.

66 65

64 63

62 61

60 57

56 55 upper ledger lines

54 53

52 51

50 47

46 45

44 43

42 41

40 37

36 35

34 33

32 31

30 27

26 25

24 23 lower ledger lines

22 21

20 17

16 15

14 13

12 11

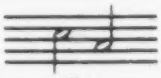
10

Thus, for example, line two of the staff will be named (according to the interpretation just given) by '011101'. Sequences of binary digits will be used also, as explained below, to name other attributes of primitive symbols.

The output words produced by M each will consist of 16 binary digits.[11] The three leftmost digits of an output word will be called the 'tag' of that word (Output words having the same tag correspond roughly to CCMN primitive symbols of the same type: e.g., all output words corresponding to notes have tag '000'; all output words corresponding to rests have tag '001'.)

Excepting output words whose tag is '110' or '111', the fourth binary digit from the left of an output word will always be 1 unless the output word corresponds to the first primitive symbol in its scanning unit that is scanned. I.e., the second of two consecutive output words contains 1 in its fourth bit position if and only if the symbol to which it corresponds is in the same scanning unit as the symbol to which the first of the two output words corresponds. Thus does M differentiate (a) from (b):[12]

(a)



(b)

The remaining twelve bit positions (bp) of an output word contain the information summarized in the following chart and explained illustratively in the remainder of this essay.

[11] Exclusive of any 'error-detecting' or 'error-correcting' bits that it may be thought advisable to include.

[12] Assuming that the higher of the two notes in (a) is notified by M first.

Output word corresponding to:	Tag bp 1-3	bp 4	Field A bp 5-10	Field B bp 11-12	Field C bp 13-16
note	000		staff-position	stem-direction	note-duration
rest	001		staff-position	00	note-duration
dot	010		staff-position	00	0000
groupette number	010		1111	bp 9 groupette	16 number
dynamic mark	010		000001	00	dynamic mark
bracket	010		000010	bracket	0000
phrase-mark	010		000011	phrase-mark	0000
special sign	010		000100	bp 11 special	16 sign
accidental on staff	011		staff-position	00	accidental type
accidental above staff	011		111111	00	accidental type
accidental below staff	011		000001	00	accidental type
clef	100		staff-position (See explanation)	clef type	0000
barline	101		000001 (See also footnote 19)	barline type	bp 13-14 repeat signs; bp 15 end staff; bp 16 end system
text if to left of staff beginning	110	1	BCD letter	bp 11 BCD	16 letter
text otherwise	110	0	BCD letter	bp 11 BCD	16 letter
time-signature numerator	111	0	bp 5 time-signature	16 (See explanation)	
time-signature denominator	111	1	bp 5 time-signature	16 (See explanation)	

NOTES (tag 000)

In Field A of an output word corresponding to a scanned note, the machine M will put the sequence of six binary digits that names the staff-position on which the note-head of the scanned note is. In Field C, the machine will put a coded representation of the 'note-duration' of the scanned note: this attribute is determined solely by the shape of the note-head, the presence or absence of a stem (though not the direction of a stem nor the side of the note-head to which the stem is attached), and the type of tail (if any) attached to the stem. The following chart includes a few instances of each type of note-duration, the British and American names of each type, a table of 'distinctive features' which should serve to classify any scanned note into one of the note-durational types,[13] and the code that should be placed in Field C of the output word corresponding to the scanned note.

In connection with this chart, it should be noted: (1) that eighth notes and notes of smaller non-zero note-duration may be beamed together,[14] e.g., can occur; (2) that the chart does not include such notations (found in certain CCMN 'dialects') as 'long' grace-notes (often written just like quarter or eighth notes but in much smaller type), Sprechstimme or percussion-instrument crossed notes (e.g., ♩) or certain other sorts of notes(21), (22); (3) that the 'diamond-shaped whole-note' is used today for the purpose of indicating artificial harmonics and may have to be distinguished in some instances from the round-shaped whole note. There are five unassigned 4-bit 'note-duration' codes and it is supposed that, at least initially, judicious human 'pre-scanning' of the input compositions will be used to determine whether note-durational types additional to those specified on the chart are necessary, and if so what they should be.

The direction of the stem (if any) of the scanned note is indicated in Field B as follows: 00--no stem; 01--stem rising from note-head; 10--stem falling from note-head; 11--stem rising from note-head and (another) stem falling from note-head (e.g., ' 𝅗𝅥 '). (Since half-notes differ from whole-notes chiefly in the presence

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[13] These features do not determine, given any symbol, whether it is a note.

[14] Occasionally, as part of a tremolo indication, half-notes may be beamed together.

Distinctive features

Instances	British name	American name	Is note-head rectangular?	Is note-head black?	Is there a stem?	How many tails?	Is tail crossed?	Code
	long	long	yes	no	yes	0	no	0000
	breve	double-whole	yes	no	no	0	no	0001
	semi-breve	whole	no	no	no	0	no	0010
	minim	half	no	no	yes	0	no	0011
	crotchet	quarter	no	yes	yes	0	no	0100
	quaver	eighth	no	yes	yes	1	no	0101
	semiquaver	sixteenth	no	yes	yes	2	no	0110
	demisemiquaver	32nd	no	yes	yes	3	no	0111
	hemidemisemi-quaver	64th	no	yes	yes	4	no	1000
	?	128th	no	yes	yes	5	no	1001
	grace	grace	no	yes	yes	1	yes	1111

and absence, respectively, of at least one stem touching the note-head, and a similar difference distinguishes longs from breves, it may be advisable to eliminate the stem presence-or-absence feature detector and hence assign the same Field C code to longs and breves, and to whole and half notes, relying for further discrimination on the stem-direction feature detector whose decisions are reported as Field B.)

RESTS (tag 001)

Field A contains the six binary digits that name the staff-position on which the rest is. Field B contains 00. Field C contains the code, indicated in the following chart, that represents the 'note-duration' of the rest. (There are no grace rests.)

MISCELLANEOUS SIGNS (tag 010)

The category 'miscellaneous signs' includes the dot, the numerals that constitute a groupette number, dynamic marks, brackets, phrase-marks, and other signs.

a) Dots

Field A of an output word corresponding to a scanned dot (' . ') contains the six binary digits that name the staff-position on which the note is. Fields B and C contain 000000. The dot is used in CCMN to indicate both note-durational prolongation and staccato performance (according as the dot appears just to the right of a note-head or rest, or just above or below a note-head). Discrimination between these two types of indication is not expected of M; rather, this discrimination will be achieved by later comparison of the staff-position[15] of the dot with those[15] of neighboring notes and rests. If Field A of an output word with tag 010 contains digits that represent (in the binary system) a number greater than 110110_2,[16] or less than 001000_2, then the output word does not correspond to a scanned dot.

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[15] As recorded in data output by M.

[16] In the few cases in this essay where a sequence of Arabic numerals denotes a number but does not denote according to the decimal system, the radix of the number system according to which the sequence does denote is indicated by the subscript placed after the last numeral in the sequence. (The subscript denotes according to the decimal system.)

Distinctive features

Instances	British name	American name	Number of staff lines symbol touches	Is top of symbol at a staff line?	Is bottom of symbol at a staff line?	Is symbol rectangular?	How many 'cups' on symbol?	Code
	long	long	3	yes	yes	yes	0	0000
	breve	double-whole	2	yes	yes	yes	0	0001
	semi-breve	whole	1	yes	no	yes	0	0010
	minim	half	1	no	yes	yes	0	0011
	crotchet	quarter	x	x	x	no	0	0100
	quaver	eighth	x	x	x	no	1	0101
	semiquaver	sixteenth	x	x	x	no	2	0110
	demisemiquaver	32nd	x	x	x	no	3	0111
	hemidemisemi-quaver	64th	x	x	x	no	4	1000
	?	128th	x	x	x	no	5	1001

Note: 'x' in the $(i,j)^{th}$ column of the 'distinctive feature' table indicates that feature numbered j is not relevant for distinguishing symbol numbered i from other rests. Note also that one of the second and third listed feature detectors is redundant.

b) Groupette numbers

The term 'groupette' is used as a generic name for duplets, triplets, quadruplets, etc.: a groupette can usually be identified by the appearance of an Arabic numeral or a sequence of two Arabic numerals (called the 'groupette number' of the groupette) placed near the groupette, whose elements usually are beamed together or associated by the extremities of a bracket or a phrase-mark. A tag-010 output word the contents of whose Field A is (according to the binary system) greater than or equal to 111100_2 corresponds to the scanning of a groupette number, and bp 9-16 of that word are reserved for the specification of that number in some fashion. Arabic numerals are used in CCMN also for time-signatures and to suggest 'fingerings' in instrumental music.[17]

(Time-signature numerals are usually larger than groupette numbers, which are usually larger than 'fingering' numerals (which are ignored by M).)

c) Dynamic marks

Field A contains 000001; Field B contains 00. Field C contains the code shown in the following chart beside an instance of the particular dynamic mark that is scanned.

pppp	- 0001	mp	- 0101	fff	- 1001
ppp	- 0010	mf	- 0110	ffff	- 1010
pp	- 0011	f	- 0111		
p	- 0100	ff	- 1000		
beginning of crescendo sign	('<') - 1011	end of crescendo sign	- 1100		
beginning of decrescendo sign	('>') - 1101	end of decrescendo sign	- 1110		

Dynamic marks often are printed in a special type fount. Occasionally the words (or portions of the words) for which the dynamic marks are abbreviations are printed, but these words are considered in the present essay as text.

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17 And, in older music, to suggest an harmonic realization: the so-called 'figured' bass. The ability to 'read' figured-bass is not specified of M.

d) Brackets (i.e., '⌈‾‾⌉' or '⌊‾‾⌋' or sometimes '⌈‾‾⌉', etc.)

Field A contains 000010; Field C contains 0000. Field B contains 01 if the beginning of the bracket occurs in the scanning unit; 10 if the middle[18] of the bracket (i.e., a straight line--sometimes broken once to allow for placement of a groupette number--not necessarily parallel to the staff lines) occurs in the scanning unit; 11 if the end of the bracket occurs in the scanning unit.

e) Phrase-marks

Field A contains 000011; Field C contains 0000. Field B contains 01 if the beginning of the phrase-mark occurs in the scanning unit; 10 if the middle[18] of the phrase-mark occurs in the scanning unit; 11 if the end of the phrase-mark occurs in the scanning unit. To the following scanning unit:

four output words from M would correspond: one for the note, and three for the phrase-marks (one of each type). Phrase-marks are used in CCMN to indicate both slurs and ties, but M is not expected to distinguish slurs from ties.

f) Special signs

Field A contains 000100; Fields B and C together contain a six-bit code that specifies a particular 'special sign'. Realizations of M may 'read' none or some of the following signs--this will depend on the cost of including these 'optional' signs. The following list of signs (beside which six-bit codes have been put) could be expanded easily to include signs found in various CCMN 'dialects'.

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[18] By 'middle' is meant here a non-initial and non-terminal part.

—	--	000001		--	001110
+	--	000010		--	001111
o	--	000011		--	010000
∩	--	000100		--	010001
v	--	000101	sfz	--	010010
^	--	000110	sffz	--	010011
>	--	000111	rfz	--	010100
⌒ or ⌣	--	001000	rffz	--	010101
tr	--	001001		--	010110
	--	001010	(	--	010111
	--	001011	)	--	011000
~	--	001100		--	011001
	--	001101		--	011010
				--	011011
				--	011100

ACCIDENTALS (tag 011)

Field A contains the six binary digits that name the staff-position on which the scanned accidental is (if the accidental is above or below the staff, Field A contains 111111 or 000001, respectively). Field B contains 00. Field C contains the code listed beside an instance of each accidental:

♯	--	0001	✖	--	0100
♭	--	0010	♭♭	--	0101
♮	--	0011			

The distinction between accidentals in a key-signature ('permanent' accidentals) and other, 'measure' accidentals is not made by M but can be made easily in further processing of the data output from M. The double-flat ♭♭ may appear in free

variation with two consecutive, single, flats ♭ ♭ but this presents no problem: in the first case, M will output one tag-011 word; in the second place, two tag-011 words.

CLEFS (tag 100)

There are three clef types in CCMN: the G-clef (' 𝄞 '), the C-clef (' 𝄡 ' or ' 𝄡 '), and the F-clef (' 𝄢 ' or ' 𝄢 '). The codes for these clef types are 00, 01, and 10, respectively. Each clef type may be 'located at' one or more staff lines (never a ledger line or a space). The G-clef is located at that staff line which is encircled by the loop portion (' 𝄞 ') of the G-clef sign (in nearly every case, this will be the second staff line). The C-clef is located at that staff line which bisects the C-clef sign, i.e., occurs here: (' 𝄡 '). The F-clef is located at that staff line which lies between the two dots of the F-clef sign. (These dots are part of the F-clef sign and perhaps should be recognized by M together with the rest of the sign as one unit. We shall presume here that this is the case.)

The output word corresponding to a scanned clef (i.e., to a scanned clef type located at a particular staff line) is formed by setting Field A of the word to the six binary digits that name the staff-position at which the clef type is located, by setting Field B of the word to the code specified above for the particular clef type scanned, and setting Field C of the word to 0000. Fields A-C of the output words corresponding to the frequently-used CCMN clefs are the binary digits that denote (according to the binary system) the numbers whose octal representation is placed here beside the name of the corresponding clef:

Treble	--	3500	Tenor	--	4120
Soprano	--	3320	Baritone	--	3740
Mezzo-soprano	--	3520	Bass	--	4140
Alto	--	3720			

BARLINES (tag 101)

A barline is a straight line perpendicular to the staff lines that (usually) intersects all five of them. It frequently extends beyond the staff to intersect neighboring staffs. A barline may be thick or thin (a thick barline is always followed or

preceded by a thin barline in the next or immediately previous scanning unit: the conjunction of these two types of barline forms a so-called 'thick double barline'). A thin barline may be either 'segmented' (i. e., composed o unattached line segments) or 'regular' (i. e., composed of a solid line).

If two dots (usually one each on the second and third staff spaces--i. e., the staff-positions named by 011110 and 100000) follow or precede a barline immediately, a 'repeat sign' is formed. In the present essay, we have treated the repeat-sign two dots, like the F-clef two dots, as belonging to the same scanning unit as the repeat-sign (or F clef). Conceivably, implementation of M might be easier if these dots were treated as belonging to an adjacent scanning unit. (Clearly, only minor modifications of the structure of M's output words would be necessary to effect this change.)

Field A of an output word corresponding to a scanned barline contains 000001. Field B contains the code representing the barline type. The code is as follows: thick barline -- 01; solid thin barline -- 10; segmented thin barline -- 11. bp 13-14 contain 00 if there are no repeat-sign two dots adjacent to the scanned barline; 01 if such dots are on the left side of the scanned barline only; 10 if such dots are on the right side of the scanned barline only; 11 if such dots are on both sides of the scanned barline. bp 15 contains 1 if the staff ends with the scanned barline--i. e., if the scanned barline is in the last scanning unit on that staff.[19] Otherwise, bp 15 contains 0. It is possible that, for some compositions, a realization of M can determine the end of 'systems' of staffs--either because all the staffs in the system are initially 'braced' together by a symbol such as '{', or because the barlines run through the staffs in a system and no further, or because of the presence of one or another system-demarcating symbol such as '//' or '=='. If the machine has the capability of recognizing ends of systems then this can be indicated in bp 16, which is set to 1 only if the scanned barline ends the last staff in the system (hence

[19] A composition in CCMN generally is such that the last scanning unit on each staff includes a barline. Occasionally this will not be the case: for instance, if the composition is written without barlines, or if a measure is left incomplete at the end of one system of staffs to be completed at the beginning of the next system. An end of a staff whose last scanning unit did not include a barline may be indicated by M as a tag-101 output word with bp 4 set to 0, Field A set to 000010, and bp 11-14 set to 0000.

bp 15 must in this case be set to 1). Otherwise, bp 16 is set to 0.

TEXT (tag 110)

If a realization of M can 'read' alphabetic characters and punctuation, this machine can output six-bit representations of two of those symbols in a tag-110 output word.[20] The type fount (e.g., italic, bold-face) could be indicated by the use of a 'special' six-bit indicator. If text is placed to the left of the beginning of a staff, the text is likely to name the instrument scheduled to 'perform' the staff. This type of text is distinguished from all other text by setting bp 4 to 1 in this case only.

TIME-SIGNATURES (tag 111)

The following time-signatures occur in CCMN (excluding certain 'dialects' of CCMN): 'O'; 'Φ'; 'C'; '¢'; time-signatures consisting of one or two (consecutive) Arabic numerals; time-signatures consisting of two sequences of Arabic numerals, one sequence placed above the other, and each sequence containing one or two numerals. Each of the above-specified time-signatures except those of the last-to-be-specified type will be called 'denominator-free'. If a denominator-free time signature is scanned by M, the corresponding output word has 0 in bp 4 and Fields A-C have, right-justified with leading '0"s, representations[20] of 'Ø',[21] 'Ø/',[22] 'C', 'C/', and the numeral sequence, for each of the above-specified types of denominator-free time-signature, respectively.[20, 22] If a time-signature not denominator-free is encountered by M, two output words result. The first of these represents the numerator of the time-signature--i.e., the higher-placed numeral sequence--and the second of these represents the time-signature denominator--i.e., the lower-placed sequence. bp 4 of the first word is set to 0; bp 4 of the second word is set

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[20] A standard six-bit 'binary-coded decimal' (BCD) representation of alphanumeric characters can be used.

[21] 'Ø' is a letter, '0' a numeral/

[22] The representation of a conjunction of symbols can well be the conjunction of their individual representations.

to 1. (Since a time-signature alone usually occupies one scanning unit, these settings should conform to the normal (i. e., excluding tag-110 words) settings of bp 4 in output words corresponding to a scanning unit.) Fields A-C have, right-justified with leading '0''s, representations of the appropriate numeral sequence.

* * *

AFTERWORD

The machine M may be viewed as a 'transducer' of the multidimensional, continuous (at least in some aspects), language CCMN into a one-dimensional language composed of two discrete elements. Viewed this way, M is similar to algorithms for converting CCMN into tangible notations for the blind[23], [24], or algorithms for converting CCMN into a format punchable on paper tape that activates a player-piano[25]. M differs from the cited 'similar' 'transducers' first because more aspects of CCMN are converted (and the conversion is direct: no passage to a pitch-representing notation is involved, and a realization of M requires only a small memory besides the stored 'dictionary' of CCMN primitive symbols) and secondly because the output from (a realization of) M is in computer-acceptable form. A system that includes (a realization of) M and a general-purpose digital computer can be employed profitably in asking and to answer many questions about music--indeed all reasonable questions whose solution is computable from the notes (and other CCMN symbols converted by M) alone. We believe that these questions are precisely those that musicologists would term 'internal-evidential'.

The output devices that could be put in this system, together with the standard high-speed alphanumeric printer and other equipment, include such music-yielding devices as a paper tape controlled, electrified, music typewriter,[26] an RCA Electronic Sound Synthesizer,[27], [28] or (requiring previous digital-to-analog conversion) a low-pass filter, magnetic recording tape, and a loudspeaker[29], [30]. The resultant system can be used practically to reduce full scores to piano scores

automatically,[31] to make critical editions (including lists of source variants) of musical compositions given different printed (and ultimately handwritten) versions of the 'same' composition,[23] to compile thematic catalogues, to test a particular theory of music 'against' a significantly large corpus of compositions for 'goodness of fit', to produce (transposed) parts from a given score or a score from given parts, to analyze or to compose music according to a given algorithm,[24] and to obtain recorded sounded-musical equivalents (at particular timbral, envelope, tempo, etc. specifications) of a given written-musical composition. We have by no means exhausted the applications. These do appear so promising that representations[(32), (40)] of CCMN suitable for key-punching on standard 80-column Hollerith cards have been developed, and recently some key-punching from CCMN has taken place. Entering musical data into a computer by manually punched cards is obviously a poor substitute in both speed and quality to optical character recognition, and key-punching has been considered therefore only a temporary operation.

A realization of M, to be acceptable, will of course have to have--given normal CCMN music as input--at least a certain speed, at most a certain error rate, at most a certain reject rate, and other minimal standards. It seems premature to attempt to specify these standards here: research on the problems involved in reading compositions in CCMN automatically has not yet progressed that far. In balancing error rates against reject rates, it seems preferable to allow the latter to increase if the former can be reduced significantly thereby, for the formation rules of CCMN not only disallow most one-dimensional or two-dimensional sequences of primitive symbols from being well-formed but in certain cases narrowly constrain the choice of primitive symbol if the resultant formula is to be well-formed. And, as in the case of written English,[(37), (38)] context can be employed to 'solve' 'garbled' messages output from M, i.e., messages that contain one or more notifications of a rejected character. Such notifications might take the form of tag-000 output words the contents of whose Field A does not name a staff-position: the intended interpre-

[23] This has been suggested in (33).

[24] See, for example, (34), (35), and (36); also, the references in (34).

tation of the occurrence of such a word being that the immediately preceding (ordinary) output word corresponds to a rejected CCMN symbol. It is quite possible that, in certain cases, M may be able to notify some information about a rejected symbol--e.g., that it was on a particular staff-position, or that it was a C-clef although the staff-position at which the clef was located could not be determined--and this sort of obviously useful information (whose obtainment is dependent upon the internal decision logic of the actual machine) might well be output in the word corresponding to the rejected character, with the following, 'reject-notification' output word specifying which bit positions of the preceding word contain reliable information about the rejected character.[25]

[25] Of course, more than one 'reject-notification' word could be output by M consecutively, if necessary.

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DISCUSSION AND COMMENTARY

CHAIRMAN: I would like to call upon Mr. Rothenberg, who has been involved in a series of experiments in perception that involves a music representational language, although not an input language with specification of pitch, rhythm, etc., like those that have thus far been discussed.

New York Research Group Perception Research

DAVID ROTHENBERG: I should say first that the work I'm going to describe has been done until recently at the New York University Computation Lab under Air Force supervision; it is now continuing at the New York Research Group, also under Air Force and joint Navy support. It deals chiefly with research in perception and peripherally with the creation of a musical language. Since it attempts to make a classification of perceptions, in particular musical perceptions, in terms of the actual units in which it occurs, it will hopefully come out in the end with a language representation of music in which the arguments of a set of statements correspond to actual perceived gestalt. There are experiments which have been designed to verify or reject the theory. If, through a deductive line of reasoning, it is shown to be correct, it is possible to derive the arguments of the statements I'm going to speak about.

Our work begins with assumptions of the gestalt theory of perception, which says that when you perceive an interval or a distance, it is mostly dependent upon--and is expressed functionally in relationship to--the entire range of stimulae in the field. Thus, the perception of a particular interval is a function not only of itself but of all other intervals you may have heard before or simultaneously.

In mathematical models, stimulae are represented as segments, some of them connected and some of them not. These are measured and classified by two functions; one, a distance function which can order them, and the other, a measuring function, which in turn is a function of the background structure. The latter is a counting function, which, like the distance function, produces an ordering. The correspondence between these two orderings is examined, and when they do indeed agree, we have what is called a measuring set, a background structure for which both these functions agree. This measuring set is assumed to have the property of being useful as a gestalt in terms

of measuring some particular stimulus. For example, if you hear musical intervals and there is in your memory a collection of intervals that meet the necessary criterion, it is assumed that any sequence of intervals forming elements of this measuring set will be measured in terms of the set. This collection of measuring sets is dependent upon the structure of the universal set, which contains all the elements that may be used; it is also dependent upon some things which constitute a permissible measurement error in the model.

There is a defined quantity called tolerance, which is the maximum distance any element may be displaced without introducing an ambiguity in measurement. In some sets, this tolerance is zero; and when the tolerance is zero, there are measurement ambiguities for some of the intervals within the set. There is also a quantity called stability, which is the percentage of ambiguous intervals in a group of intervals comprising a measuring set; the measuring sets are classified in order, according to this percentage. Both tolerance and stability are specific to individual measuring sets and in no way depend upon the structure of other sets which may be considered simultaneously. In terms of musical application, these measuring sets are collections of intervals. The entire collection of measuring sets will be represented as elements in some sort of lattice diagram, and all subsets of the universal set can be mapped onto a transform of this lattice. Subsets have been classified according to their image, which is a number under the mapping for this transform.

By way of explanation, let's for the moment consider the measuring sets to be musical scales, not musical scales in the sense that we understand them--as having a tonality or a root and a collection of tones above them--, but merely a collection of tones. This collection is then used in the same way that a ruler is used to measure, and we can measure from any point. We can deal with microtones as well. If you accept the hypotheses of interval ordering, there will be a finite number of measuring steps satisfying the conditions specified; agreement between the ordering as shown by a set of counting functions and the ordering as shown by an assumed distance function.

A good deal of music has been investigated using this hypothesis. Certainly we would assume that musical scales from all cultures should have the property of stability, and indeed they do. There is yet another property called redundancy, which has to do with the ability of one of these to carry information. For example, in any major scale redundancy would be the number of pitches that must be heard from a particular major

scale before it is possible to know it is that one and no other. In the general model, it would be the number of elements of any of these sets that you would have to hear in order to determine it is that one and none of the other possibilities in the collection. Certainly, however, the fewer the elements, the less capacity there is in an information-theoretic sense for that particular set to carry information. The model can be applied independently to rhythm as well as to pitch; the result is a similar classification for all rhythmic groupings.

If the effective theory is correct, if you represent a musical score in this language and, in coming back from the language to the score you find that the scores are not identical, the scores should be still identifiable as one and the same.

What our approach amounts to is the following: any pitch or rhythmic configuration is represented as a form in terms of the spacing between its elements. These forms can then be located in the lattices pertaining to pitch and rhythm, respectively. Using sets of statements dealing with similarly grouped classes of stimulae in our perceptive system, it should be possible to reconstruct a musical score, although the score will not be an exact duplication of the original. It is my hope that we will eventually be able to break down a good deal of music this way. For people interested in musical languages, this kind of representation may form a larger framework for more detailed representations which actually specify individual notes and durations.

IML-MIR

MICHAEL KASSLER: Kindly let me make a few general comments. I think that one of the interesting things that one finds out after participating for several years in investigations related to the whole subject of devising effective procedures to perform music and musicological tasks, is that as time advances like an arrow, so too do conceptual advances. To me, one of the interesting things is how much progress we have made in the whole notion of input languages. My first work in this area was at Harvard, where I wrote a paper which was presented at the seminar on Mathematical Linguistics. It was called "The System for the Automatic Reduction of Musical Scores." In this paper, what I did, essentially, was to devise a language for UNIVAC I, which would represent both pitch and rhythm. When I say a language for UNIVAC I, I mean

to say that certain constraints of the machine (that was the one available at Harvard) were taken into account in designing the language; it was never really implemented.

Several years later, when I came to Princeton, many of the biases and mistakes that I had made in designing the language--and I say mistakes because I wasn't really concerned here at all with the human factors problem of deciding what is the optimal language for a person to keypunch--were carried over by me into a little paper I wrote which was the first report of Project 295d; it was called "A Representation of Common Tone Music Notation," which was the name that I used to describe the system of notating Western music. This was the language notation which had such anomalies as having the person keypunch in LN3 to indicate that there was a note on line 3; L3 would have given exactly the same information. The fact that I put in LN3 rather than L3 probably reflects the conceptual state of people's thinking at this time. That is, we were trying to devise something that was in some sense a fixed format and the fact that we had an extra phase of L1 on the punched card meant that we put in the extra letter regardless of how this affected the keypunching time.

One of the advantages of a fixed format language was that it was immediately verifiable by standard verification techniques, whereas the three types of free format language which I'm going to mention do not have this advantage. The IML language was developed not by me, but by Ogden M. Jones, who is on the computer staff of Princeton University. It was modified to a very small extent by Hubert Howe, who had also devised certain techniques for making it adaptable to systems other than those I call monolinear music, that is, systems where there are simultaneous notations. But the IML language that has been implemented deals essentially only with systems of local music or music in which each part has no simultaneity. This language was based on certain earlier conceptions that I had devised. One of these conceptions is the notion of lines, which works as follows: A line of music is the written musical analog of monophonic music. There are several definitions, but one of them is that if you add all the durations of the notes in the proper addition, you are going to arrive at a time signature. In other words, there are no gaps, there are no simultaneities allowed here. You can just go along from left to right.

Basically the notation goes something like this. For every written musical composition, we may divide data into three categories. Some data are pertinent to the composition as a whole, such as the name of the composer, the name of the publisher, the name of the librettist. There are also data that are pertinent to each line, such as the key signature, the time signature, the clef symbol. Lastly there are data that are pertinent to each note, such as whether it is preceded by a sharp, whether it has an accent suggested by the editor, or whether it is dotted. I might say initially that the keypuncher has the option, which he can indicate by a special control symbol, of deciding whether he is going to keypunch in the clef as written--if he's a musician he can do this--or whether he's going to keypunch everything as if it were in the treble clef. He has this option and he can switch to it and from it more or less at will.

The information pertinent to the piece as a whole is encoded in things called pertinent analyzable comment, which go something like this. A person will input an apostrophe on a word like "composer"; then he has 36 letters to indicate the name of the composer.

Everything is a free format. . . A conversion program takes as input the punched cards and presents as output magnetic tape records which are sorted according to what we call absolute attack time within the system. A record for each note will appear in the order in which the notes appear in time, so to speak, with higher notes coming before lower notes if they are simultaneous. The information will include not merely the data in a binary form, with 36 letters for each note or rest, but will include also converted information, and that is why the conversion program has its name. The converted information will give the absolute register class and the pitch class from 0 to 11 in each case. It will have included the key signatures, the clef, and the instrument transposition in arriving at this. It will also include attack time within each measure.

The step after this is being undertaken jointly by Toby Robison and myself at Princeton. This is a higher level language, a MACRO language which we call MIR. It stands for Musical Information Retrieval. We will want to retrieve information that has been converted by the conversion program. We will want to allow the musi-

cologist to, say, go to note 5 on line 3 in measure 4. If this note is an A-flat, or if the interval between this note and the preceding note or the interval between this note and any other note is a tritone, we will want to be able to jump to part six of the program and start tabulating tritones.

Let me say one or two words about the future. There are several new devices that have taken the place of keypunches. One of them was recently announced by Mohawk Data Sciences, Inc. of Herkimer, New York. It allows a person to work directly with the magnetic tape. It is an input typewriter with a memory that also has some fancy formatting possibilities and may revise the fixed format approach to language to one that allows instant viability.

I've now given you enough information so that when Eric Regener points out the several advantages of his language, you will see that his language, which came still later, is another step along this road to conceptual advancement.

A Multi-pass Linear Music Transcription

ERIC REGENER: The language I will describe is called LMT, for Linear Music Transcription. It is a 48-character keypunch code specifically designed as input to music-analytical computer programs. I developed LMT at Princeton in the winter and spring of 1964 together with Tony Robison, another graduate student in the music department there. This language has not yet been implemented by computer programs to any extent: I will be doing this work next year as part of my doctoral dissertation. In this connection, LMT is only part of a project whose aim is a complete and very flexible system for analysis of existing music by computer (for which I will perhaps use the mnemonic SAM if no one else has used it by then). This system will take its input from an assembler program for keypunched LMT code, perhaps alternatively from direct optical scanning by computer of microfilmed scores (a project which I am also working on, not, I must say, with great hopes of success).

LMT is a "multi-pass" transcription: that is, the notated pitches, durations, and other elements of the score are transcribed separately, not all at once. The notated duration of a note is coded in one part of the transcription, its pitch (inferred

from clef and staff position) in another part, and so on. The most serious drawbacks to this method are its high potential for introducing correlation errors and the partial duplication of control systems in moving, say, from one part or line within a part to the next in several passes. Its good points, however, are numerous. First, the transcription can take advantage of the high redundancy present in the separate elements of a musical score which they do not possess together (of course, I am speaking primarily of old music); for example, repetitions of rhythms or groups of rhythms can be coded in greatly abbreviated form, though the pitches corresponding to these rhythms may have no comparable regularity. The LMT code provides many ways of indicating these abbreviations.

Another advantage to LMT as compared to one-pass codes is that the keypuncher is only looking for one element of the music at a time; he can transcribe very quickly all the indications relating to this element, without the danger of omitting indications of another kind. This advantage becomes more apparent in the transcription of complicated scores (e.g., on the level of Beethoven piano sonatas), though tests we have run at Princeton indicate that LMT is almost as efficient as IML (the Princeton one-pass code) in transcribing Masses of Des Prez. In a complicated score (i.e., with simultaneities in one part, articulative and expressive marks, etc.) a one-pass code tends to bog down, for with the symbol for each indication other symbols have to be introduced to show what kind of an indication it is, resulting finally in the necessity for a complicated switching operation between the different kinds while transcribing a given note. In LMT, each pass transcribes its own kind of indication; this procedure also makes possible a great variety of different symbols in each pass.

LMT is a "complete" code, in that all indications present in any printed score in conventional notation can be transcribed by suitable definition of symbols. For many analytical applications, however, it is not necessary to consider the complete score. In these cases, LMT passes can be coded for a given piece which transcribes the information of interest; later, if the rest of the score is needed, other passes can be coded and combined with the existing material. No other code that I know of embodies this concept to any extent.

Again, using the transcription of a given edition or source of a piece as a basis,

the transcription of another source can be "produced" by overlaying a pass containing alterations or corrections peculiar to that source, without the necessity for punching an entire new transcription. This capability should be useful to people making correlation or "tree" studies of manuscript sources, a field which I think everyone agrees should be mechanized as soon as possible.

LMT uses alphabetic symbols for all musical "events" (i. e., duration-symbols, pitch-symbols, etc.) occurring in the printed score. These alphabetic symbols can be redefined at will to suit the user's preferred mnemonic code, or new symbols may be defined for particular applications. In the pitch- or note-pass, the first seven letters of the alphabet stand for the diatonic note-classes. Register of a note is coded by a relative indication entirely similar to that in Mr. Brook's one-pass code; a U before a note-symbol shows that the next code is in the octave above the one preceding, and L shows that it is in the octave below, two U's show that it is in the second octave above, and so forth. If a note is within a fourth (of any species) above or below the preceding note, no register code is necessary. Chords are notated from the highest note down inside a special field, an assumed L preceding all notes after the first.

In the rhythm pass, arbitrary single-letter codes are defined for the various self-contained duration symbols. Letters X after a coded duration symbol indicate dots of prolongation after the corresponding note; a slash (/) in front of the symbol indicates a rest of that duration. An arbitrary single-letter prefix on a symbol indicates the corresponding triplet value; any irrational duration can be indicated by defining this kind of code (if occurrences of this duration are frequent) or by a special "groupette-field" (if they are not).

Numbers are exclusively reserved in the main part of the code for indicating repetitions of a given symbol or group of symbols. Thus if "F" represents a sixteenth note in the rhythm pass and parentheses enclose notes beamed together, then "4(4F)" indicates four beamed groups of four sixteenth notes.

The eleven "special" (i. e., neither alphabetic nor numeric) symbols indicate such things as part changes, line changes within a part, ties, barlines, repetitions of groups of notes or whole measures where indicated after their occurrence, simultaneities on a single line (chords), special fields (for clef, time signature, etc.),

rests and beaming. Some examples of these are shown above. Special control cards outside the sequential transcription give identification of the piece being transcribed, define new symbols to be used in the transcription, and define abbreviations for frequently-occurring sequences of symbols, among other things. I am now extensively reworking this section of the language to make it both simpler and more powerful. As I indicate in my manual,[1] I would like to include a capability for user definition of MACRO's, by which abbreviations for sequences of symbols would be defined with space for variable parameters to be inserted in the process of coding. I will also include options to indicate to the LMT assembly program exactly what information the analytic programs will require and hence what coded information may be omitted from a given assembly of a piece. This capability will make the analysis programs more efficient, in that they will be given only the data they require for a given run. I will come out with a new, completely revised version of LMT sometime in the fall; until then, I must apologize for the unavailability of the old manual. The language as described in the old manual will not be compatible with the new version in any case; still, since some people have found if useful in developing their own languages, I suppose it has served a useful purpose.

* * *

HARRY B. LINCOLN: My particular application of computerized techniques is the thematic index. I am interested in a rapid method of denoting incipits, other than copying the incipit itself on my cards. Further, I wish to have the computer extract the interval sequence of the incipit from the input language. Finally, for publication, I shall wish to print a thematic index of selected cards with the expectation that the print-out will present a page ready for offset reproduction. It is the last need, of course, which particularly attracts me to the Photon code. My print-out is not a complicated score replete with expression marks requiring paste pot and hand finishing. Once I have entered the code for the incipit I am forever through with further worry about future autography (with possible errors), no matter how many or in what order the material will be used.

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[1] Eric Regener. *A Linear Music Transcription for Computer Input.* Princeton University Music Department, March 1964 (mimeographed, out of print).

I have entered enough incipits in Photon code to be convinced that it is easy to learn and is as mnemonically oriented as any other code thus far presented.

FRITZ A. KUTTNER: It seems too early for final conclusions on the respective merits and limitations of the various input languages proposed so far. There are now at least five such languages, and additional ones are being developed in several locations. This fact alone suggests that the search and effort for a universal standard language is premature and comes at a time when experience with languages is far too limited. It also indicates that a universal language covering all possible requirements and special needs would be (a) much too complex to be practical, (b) not really possible, (c) not even desirable.

The elements of the translators proposed and discussed so far show clearly which particular applications their originators had in their minds, e.g., mainly library functions: music printing and publishing techniques: or research into primitive and non-western musics, etc. We may thus expect that the future will produce many more languages, most of them designed for some specific research project or need. This is desirable and legitimate because no language to date can claim to cover the requirements of every conceivable objective. It is also evident that no language has had sufficient time to prove its superiority in published reports on a variety of successfully completed research topics. In fact, there is no major music-computer project that has been successfully completed and published as of this writing.

The repeated warnings against a future Babel of input languages seem exaggerated and unrealistic to me. General acceptance of any translator on a national or even international basis would be an objective that cannot be achieved by ardent persuasion; but it might gradually develop from experience and proof of superiority in practical application over a number of years. Such accepted standard language will probably contain features from quite a few proposed translators.

One cannot help feeling that the "war of the languages" is a waste of energies and efforts, and the various originators may be in for severe disappointments and frustrations in their pleas for universal acceptance. Standardization of any kind is a gigantic undertaking bound to fail time and again and to run permanently into all sorts of re-

sistance, including irrational, psychological, and national idiosyncrasies. If we would concentrate our future efforts on practical application and testing of languages rather than on urging their general acceptance, much more real progress could be made. (The fact that, e.g., none of the languages published so far can satisfy my own specialized research needs, is just one indication of what we must expect of input translators in the future.

In particular, future languages will have to overcome a specific weakness more or less common to the translators published so far: most musical events are quantities or are represented by quantities. It is unsatisfactory to code such quantities in terms of words or letters and leave it to the data processor and unnecessarily complex programming jobs to re-translate such alphabetic coding into digital form. For this speaker at least, a practical language should express quantities directly in digital form, which permits output data to be read and understood in the same digital form. This basic requirement makes it clear that a "library language," a "music printing language," and an "analytical research language" call for different approaches which are mutually reconcilable only by compromising basic needs of the task at hand.

GEORGE W. LOGEMANN: In opening, I would like to state that for the time being, it may not be a good idea to standardize a language. We have had several interesting and useful ideas presented. Perhaps I can show you that it is possible to allow the researcher quite a measure of notational freedom as long as he is consistent.

First let me point out that I am discussing a keypunching language for reading musical data into a computer for purposes of information retrieval and analysis. Thus, in addition to notes and attributes of the notes, one may wish to keypunch information concerning the tonal structure, or the melodic phrases, or what have you. We saw, for example, that Mr. Wenker had other variables which pertain more to the way the music is practiced than to the way it is written. The notation he uses could actually indicate inflections which the performer would add to the music. And Mr. Forte had an interesting idea for representing music in which the melody moves from instrument to instrument: with each notehead, he would indicate which instrument is playing that particular note: conventional schemes would find it rather difficult to treat this type

of melody. For a more comprehensive approach to notation, we might combine elements of several languages and allow the researcher to define the language as he would like to use it.

Obviously, one's choice of language dictates the structure of the assembler. That is the portion of the analyst's computer program responsible for reading information. The technique I advocate will allow us to tailor the notation to deal with a particular problem. The result is a language technique sufficiently powerful to describe properties of any essentially linear phenomena such as music, or dance, or poetry and other literature. In addition to allowing the researcher a choice of notation, the technique will allow him to use as many passes as he sees fit. The task of correlating information is left to the computer. If he wishes, he can condense certain notational passes for one piece and leave them separate for another. The essential idea is to specify the syntax of a language at the time it is used. Thus for musical data, I propose a reading program similar to the concept of syntax-directed compilers, which is one solution to the Tower of Babel problem that has arisen in the computational world.

There are two questions concerning this technique. The first, how should one go about defining syntax, and the second, why should a person use the technique at all. First let me say that the material for music or similar phenomena that we are studying, will be organized internally in a graph structure. The various passes that one makes in keypunching music really refer to different threads running through this graph structure. For example, you have a dynamic level running throughout the music, and parallel to it, you have pitch levels, then instrumentation, etc. These are the threads of the graph: across it, you have the linkages and the fact that a note occurs at a certain point, with certain dynamics, played by a certain instrument, etc. The difficult part of all this is really not in describing, but in analyzing the material once it is inside the machine. I am interested in developing a program which will allow people to obtain information from questions directed to such a graphical structure.

Now as to how to define the language, the symbols one could use would be similar to those of what is called BACKUS. This is a formalized system which I attempted to apply to one of the transient forms of the Brook-Gould notation as it was being evolved.

What one does, essentially, is to define a general class of terms with symbols and then describe the structure of that class. One would then feed in a sequence of defining symbols and start keypunching. If a group of people are working together, the machine could be loaded beforehand with the sequence of definitions they are using. If one person wanted to modify the existing set for purposes of his particular program he could just put the cards at the beginning of his code.

The assembler that works on this information must be rather sophisticated. A simplified form of assembler was developed by Michael Barnett at MIT; it is called the Shadow System. Barnett described the syntax of whatever material he was working with and then wrote a program that would go through this and split it apart into other components. We would have to do that and more.

The second main question is, why should one do this. Now there are several computer languages: MAD, PERT, FORTRAN, MPL, BALGAL, all rather similar. But if a code is written in one of these, it is virtually impossible to read it into another machine. However, if you have a syntax-directed compiler, you can feed in the definition of one of these languages and then proceed. There is also a procedure-oriented language, in which you use an elemental language to describe the concept that you are working with. We are actually closer to this second approach than to the first.

In conclusion, I would like to stress again that the ideas presented earlier should be regarded more as suggestions on how to design your own language than suggestions for a language to be adopted for all time.

SYMPOSIUM III

MUSICOLOGY 1966-2000: A PRACTICAL PROGRAM

Symposium, May 21, 1966, Queens College

WESTERN-EUROPEAN MUSIC OF THE CHRISTIAN ERA BEFORE 1400: RESEARCH AND PUBLICATION

Luther Dittmer

I wish to limit my appraisal of musicological concern during the final third of the 20th century to prognostication involving in the first place research into Western-European music of the Christian era before 1400 and in the second place the publication of musicological materials. The first subject is musicologia proprie dicta, whereas the second is ancillary.

The year of our Lord 1966 is not a year of decision for mediaeval musicology. We are not threatened with the loss of our source material, as the ethnomusicologist faces when viewing the onslaught of civilisation. The luxury of the patient sifting and winnowing of the documents of mediaeval civilisation still will persevere, while the chronicler of the 20th century often finds himself outdistanced by events. No new concepts have even appeared on the horizon to indicate a new direction to research. There is no new dynamic concept that will solve the rhythmic problems of Gregorian chant; there is no new secret art, no new Upper-Wallisian valleys preserving aspects of a continuous tradition of mediaeval music even suspected to exist; there is no concept that will permit us to transcribe music which has not been transcribable before, such as issued from the Aubry-Beck controversy of the 1910s. In short, no new methodology seems imminent. Indeed, the only new concepts that abound are ideological in nature. I refer to those concepts associated with the so-called Bitterfelder Weg, as a consequence of which all music, especially mediaeval music, was really a reflection of peasant and worker music. In this respect, I wonder why Prof. Knepler of the Humboldt University has not embraced Büchner more, for theirs is a common path for Arbeit und Rhythmus and the Bitterfelder Weg. Barring the possibility that political conditions will cause us also to tread the Bitterfelder Weg, we will be faced in the future with the same problems in mediaeval music as we have had in the past.

Nevertheless, there is a certain enthusiasm present which will carry forth into

the future that one phase of our endeavors will have been accomplished. We are finally able to gain a general perspective over the sources of mediaeval non-liturgical music. We can expect, perhaps even during this decade, a Quellenlexikon in the Répertoire internationale des sources musicales of all the practical and theoretical sources of non-Gregorian music. Facsimile publications of all pertinent musical sources will become available, before modern technology renders the book obsolete. With the publication of the first part of the large Florence Manuscript, pluteo 29, 1 today, the last large source of central 13th-century polyphony becomes available expeditiously to a larger audience. Transcriptions of music such as Hans Tischler's edition of the 13th-century motets, and his and my edition of the organa dupla, as well as the continuatio in spe of the polyphonic music of the 14th century, will finally make all the important documents readily available. Thus, musicology does seem destined in the last third of the 20th century to make available all of the practical sources of music prior to 1400 in facsimile and transcription. Thus, we shall see the passing in the next 30-odd years of the paleographic period of mediaeval musicology.

Of course, when we move with the firm belief that we shall attain mastery over our Quellenkunde, we can note that we have reached a conclusion only with polyphonic and secular musical sources, and perhaps also with musical treatises, which perhaps during this time also will have been thoroughly edited. The musical paleographer will still have a seemingly boundless supply of Gregoriana as terra incognita. It is not to be expected that more energy will be expended in the future than in the past in the publishing of facsimile or transcription of Gregoriana. Discoveries of Non-Gregoriana will become rarer, and although there will always be need of returning semper ad fontes, mediaeval musicology will concern itself with two divergent aspects of mediaeval music.

On the one hand, investigation of older music will become more intrinsic in direction of examination. Studies will involve the music itself more: style, performance, creativity, nature etc. Such investigations will be carried out by those more professionally musical among us. I believe that such studies will finally solve problems such as the personal contribution of Leoninus and Perotinus to the Magnus Liber, the question of the rhythm of Trouvère music, the transcription of the

Winchester troper, the sources of all the tenor successions in the music of 14th-century composers.

On the other hand, different kinds of investigation of mediaeval music will deal less with the music per se, and more with music as part of the septem artes liberales. Such musicologists will be primarily mediaevalists. Their proper scope of investigation will be knowledge of all res mediaevales, and their syntheses will be supported by the documentation that has been provided by musical palaeographers. From such investigations, we can expect the copious publications again that were so typical of the 19th century, except that these new studies will have greater source material available and will thus be more trustworthy. We shall expect clarification from these investigations of the rôle of music in older civilisation, a fuller account of the musical interrelations of Islam and Western Europe, a keener perception of music in the quadrivium, and a more profound appraisal of philosophic thought as it affected and was affected by music. New tools, such as the Encyclopaedia medii aevi will support general mediaeval research, just as Die Musik in Geschichte und Gegenwart has been so important to musical research.

There is one further problem connected with this music, its performance. There once was a time when music had been born with Bach. Today, we phrase our preference in other terms but we come close to the remark of Tinctoris in 1477, that "there does not exist a single piece of music, not composed within the last forty years, that is regarded by the learned as worth hearing." In short, the question is pertinent whether or not we shall develop a taste for Machaut or Perotin or Adam de la Halle comparable to that which we share for Josquin. I am not talking about our curiosity to learn of works such as Spontini's La Vestale or a Richter symphony merely because of their importance in historical continuity, and thus similarly that we listen to Leonin or Philippe de Vitry because we realize what this music portends for the entire course of Western musical civilisation, I mean specifically whether we shall regard this music as worth hearing, or whether we, like Tinctoris, will falter on the hearing of the music of the Chantilly manuscript. Furthermore, can an historically acceptable performance satisfy us musically or does the Sederunt principes require a Beethoven orchestra and chorus for presentation. I can make no prediction here, except to say that it will become more the duty of the musicologist in the future

to be aware of the problem of our aesthetic attachment to this music.

I wish to consider the question of music publishing to a much lesser extent, since it is not specifically a musicological problem. It is well known that music publication is extremely difficult, time consuming, and consequently more expensive than most other types of publication. Hopes for improvement rest with technology, and there are some indications that machinery may be developed to aid in music printing. Nevertheless, two factors combine to make the publication of musicological materials horrendously difficult and expensive: 1. the cost of music setting and plates, and 2. the limited market for such publications. Barring new technological methods that may solve these problems or massive financial aid, we can expect in our mechanizing civilisation that costs of publication will rise at the square of the increase in size of the musicological fraternity. Germany with its subsized presses will continue to publish most of the musicological works, and we shall look back with great pleasure to the year 1966 when it cost only $15,000 to print the Carmina Burana facsimile.

NEW DIRECTIONS FOR STYLE ANALYSIS

Jan La Rue

It's possible that I am speaking here this afternoon under false pretenses: Professor Brook invited me to join a panel discussion on the subject of "Musicology 1966-2000." Now that's an impractical subject, so I came prepared with a few suitably impractical suggestions. Then someone reminded me of his subtitle: "A Practical Program." So now I'm slightly out of step with the plan. Or perhaps the plan is out of step with itself? If we reflect for a moment it becomes clear that we can only outline a practical program if we know what we are doing. But we can't possibly know what we will be doing twenty or thirty years hence. So what we need, evidently, is an impractical program. And I'm in step, after all.

The first and most impractical suggestion I should like to make is that by the year 2000 we may be able to forget about musicology entirely. By that time, if we apply enough intelligence and effort (I realize that these are two very large, very rare words), we should be able to transcribe, publish, analyze, and interpret the whole surviving corpus of historical music. That would leave room for only two kinds of musicologists: one group to predict what the composers will do next, the other group -- for by that time we will have extremely refined divisions of labor -- to check up on the accuracy of the predictions. The rest of us could retire to Tahiti. There is only one big stumbling block between us and these Elysian fields: the tendency of societies to build up bureaucracies and establishments. If we are to progress properly in the next thirty years -- i.e. towards Tahiti -- we must find a way to avoid becoming established. The best guarantee is a fully democratic representation of all segments of our Society. We are likely to neglect the youngest members, yet they are precisely the ones who will keep us freshly supplied with ideas, who will help to prevent us from becoming established, and therefore fundamentally diminished in productive activity. I therefore propose that we should immediately take steps to secure representation on all major committees of the AMS from among the group of newest Ph. Ds. If any of us finds this idea in the least unusual, he should say to himself very seriously:

I am in danger of becoming established!

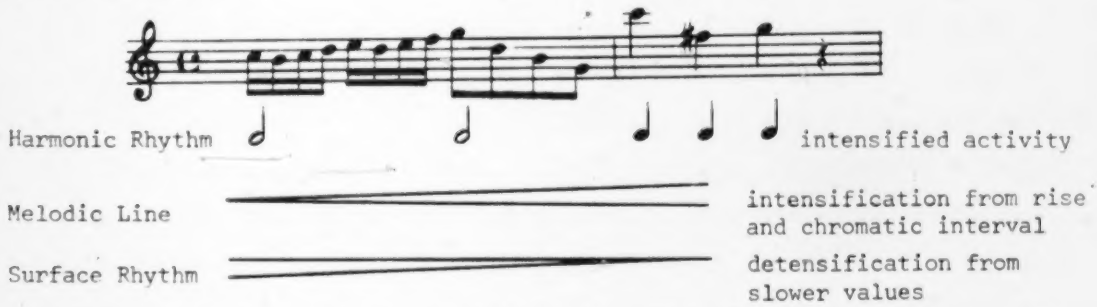
Developing further the idea that the proper goal of musicology is to eliminate itself by the year 2000, I should like to call attention to the fact that we are now on the verge of a new emphasis in musicology. In the past, musicological investigations have included three aspects: source work, analysis, and interpretation or evaluation. Up to now we have of necessity emphasized source work: bibliography, transcription, authentication, dating, collating, and so on. As our control of sources increases, however, more time will be free for analysis and interpretation. It seems likely that the next decade will solve most of the outstanding source problems, hence it is none too soon to prepare the analytical tools for a change in emphasis, a new phase in musicological activities that will stress analysis and evaluation more than source work, since much of the source work will be finished. The new phase will be welcome indeed, for it will stress work on music instead of bibliographical tasks such as thematic catalogs and watermarks. We will begin to talk more about music itself and less about its accessory problems.

How will we do it? We must evolve and apply a comprehensive theory of style analysis with special ramifications suitable to all the chronological periods and geographical areas. Some years ago I began working on a general theory of style analysis by dividing music into four elemental categories: Sound, Harmony, Rhythm, and Melody, then deriving Form as a combined function emerging from the other elements.[1] This basic plan has proved extremely useful. As the categories have become more elaborated, however, I have increasingly felt the need to go beyond even the most searching and detailed investigation of individual elements to something more interior, what we might fashionably term a sort of "depth analysis" that would reveal concinnities between the elements.

In studying any style we try to find constants -- recurrent, characteristic features that form, in the aggregate, a consistent style profile. Particularly for the great composers, however, it is often difficult to find constants in treatment of melody, or rhythm, or harmony: the master creators can always think of new procedures that defy generalizations. The internal concinnities between the elements, however,

[1] See "On Style Analysis," Journal of Music Theory, VI/1 (Spring 1962) 91-107.

seem to reflect a composer's individuality far more reliably than any single element. We become conscious of axial relationships between two or more elements that dominate a composer's whole style. For example, if a composer's main stylistic axis is between melody and rhythm, the constant factor will not be the individual character of the melodies, which may vary greatly, but rather the response that a particular melody elicits from the accompanying harmonic functions. Stated oversimply, melodic activity may balance harmonic stability, and vice versa. But the non-axial elements will show no such correlation. Comparing Haydn and Mozart, for example, Haydn's axis connects melody most directly with rhythm; Mozart's melody, on the other hand, relates more closely to harmony. Rossini's axis would connect melody chiefly with rhythm again; Debussy, who depends only slightly on melody and rhythm, makes his fundamental concinnity between harmony and sound. These inner concinnities can certainly be measured in various ways, and I suspect they may offer new insights into musical style and new approaches to questions such as authenticity and stylistic maturation.



As a concrete illustration let us examine an opening theme of a symphony of Leopold Mozart. Here the melodic interest rises over the course of the two measures both in terms of line climax and activity, matched also by increasing interest and tension in the harmony caused by the brief tonicization of the dominant at the end. The harmonic rhythm confirms the same trend, accelerating from half-notes in the first bar to quarters in the second bar. By contrast, however, the rhythmic activity runs counter to these concinnities, steadily decreasing over the two bars. Speaking merely from this tiny example, we might say that there is an axial relationship between melody and harmony in Leopold Mozart's music, but that rhythm apparently does not correlate. And in a broader study of his music, one often notices that his treatment of rhythm rarely equals other elements in expressive control.

In pursuing correlations of this sort it is soon clear that we need to call upon the most advanced of analytical tools, the computer, to make the thousands of comparisons and other tests that even a fairly simple grid of correlations requires. I should like to suggest that computer analysis will become one of the most important directions in musicology for the next generation. One hears frequently the comment that computers will make musicology mechanistic. Bear in mind, however, that the computer does what it is told: even its most sophisticated procedures depend on the imagination of the researcher for instructions; and the final results always require further interpretation. In these two functions -- instruction and interpretation -- the researcher controls the fundamental musicality of the investigation. If the results are mechanistic, he cannot blame the computer.

A less obvious and hence potentially more dangerous side-effect of computers may result from the tendency to emphasize problems that can be readily adapted to machine study. Again, however, the danger lies less in the nature of the computer than in human nature and its tendency to prefer the easier and quicker solutions. The new musicology, however, will demand complete rather than merely quick answers. Here the word "complete" deserves special attention. Up to now, style analysis, if present at all, has usually been intensely personal: stylistic remarks have emerged more from the orientation and preferences of the musicologist than from the music. Try this little parlor game: select an article by a well-known musicologist. If he is a singer or a choral director, you will notice immediately how perspicacious his remarks about melody and vocal writing will be. On the instrumental side I often have to laugh at myself. Recently I was reviewing the concertos of Ernst Eichner, an excellent Mannheim composer. I had three works at hand, concertos for keyboard, bassoon, and clarinet. Being a clarinet player myself, which concerto do you think I found most worthy of comment?

What can we do about this? May I recommend the computer to you as an instrument without human prejudices. It has its own prejudices, numerical and procedural. But these often act as stimulants and correctives, as healthy balances and supplements to human attitudes. With this new aid, the coming generation of musicologists should develop a style analysis that is comprehensive rather than selective, broad rather than personal, and rich in musical insight.

THE HISTORY OF THEORY

Edward Lippman

Like many other branches of musicology, the history of theory is still in a rather early stage of development. No end can be seen to the tasks that remain to be accomplished. We cannot continue to reprint and translate and update Riemann's Geschichte der Musiktheorie indefinitely; this work is now 68 years old, and it is not only restricted in its point of view but to a great extent superceded in its scholarship. Yet an adequate groundwork for historical studies will not be laid for some time to come. It may be easy to criticize Riemann's synthesis, but it dampens our critical enthusiasm somewhat to realize that a hundred years may have elapsed before his achievement is surpassed or even equalled. Only a "crash program" will bring us to a comparable stage of our subject by the year 2000. But the last thing I wish to suggest by this term is speed at the sacrifice of thoroughness, for much of the work that is now being done is careless and superficial, and does not meet modern standards of accuracy and completeness.

In the area of bibliography, the International Inventory of Musical Sources has undertaken the task of preparing an exhaustive catalogue of medieval manuscript treatises. Similar bibliographies would be valuable tools for further research in other epochs as well, notably, an inventory of manuscript sources for the centuries after 1400, an inventory of incunabula in music theory, and a bibliography of printed sources from the 16th century on. Library catalogues and general bibliographies offer some aid in these fields, but at the moment we are insufficiently informed not only about the location of theoretical sources, but also about the whole extent of our material and the actual number of extant treatises.

The publication of critical editions of theoretical tracts has been making some progress in recent years, thanks particularly to the Corpus scriptorum de musica of the American Institute of Musicology. The editions of this series, in contrast to those of Gerbert and Coussemaker, attempt to take all the available versions of a particular treatise into consideration, and they proceed with much greater caution in

the preparation of both text and diagrams. For the most part, they adequately present manuscript variants and judiciously select the textual alternatives they take as representative. Critical editions, however, should be supplied not only with a critical apparatus, but also with an index containing names and technical terms, with a detailed bibliographic discussion including paleographic characteristics and a stemma of known manuscripts, and with annotations or a commentary that defines and elucidates important terms and concepts, describes their lineage, and identifies all obscure references in the text. We might ask, in addition, for a translation into a modern language on facing pages. In many of these respects, the editions of the Corpus scriptorum de musica are deficient, as indeed are most purportedly critical editions of theoretical works. Time is not taken to meet scholarly requirements or to apply them uniformly. On the other hand, the difficulties are obviously considerable. Annotation and translation really partake of interpretation and internal criticism in their nature, while interpretation in turn depends upon a larger grasp of the history of theoretical conceptions. Thus although critical editions are the foundation of history, they can be improved only as our historical understanding improves. In view of the interpretive character of translation, especially where medieval and Renaissance treatises are concerned, it would be best to avoid in the future the characteristically American practice of publishing translations unaccompanied by the original text. Both translation and annotation will be greatly facilitated by the historical dictionary of theoretical terms that is being prepared under the editorship of Hans Heinrich Eggebrecht and that hopefully will appear before too many years have elapsed. Although such a dictionary is of course dependent upon previous critical editions and interpretive studies, it will considerably lighten the task of future scholarship in this field.

In the province of printed treatises we have no general series of critical editions at all, but only sporadic individual publications varying in approach and standards. The Documenta musicologica are of course simply facsimiles, and in addition will cover for years to come only a pitifully small extent of their field. The projected critical edition of the writings of Rameau is almost the only significant sign of progress in the area of printed theoretical sources, and we can only hope that it will inaugurate the activity that is long overdue as a basis for the history of theory from

the Renaissance to the recent past.

The interpretation of texts logically follows upon external criticism. This is the stage, evidenced by articles and monographs on individual treatises and theorists, in which the history of theory remains for the most part today. Even here, however, we have attended more to problems of attribution and biography than to true internal criticism. In medieval compilations and florilegia, where no interpretation is called for, we have been notably more successful, although problems of borrowing, adaptation, purpose, and influence are far from fully explored. The area of internal criticism is a key to the general progress of the field; it depends upon textual criticism but in turn makes possible larger historical studies. The relationships are exact analogues of those of the study of style, where the stylistic analysis of particular works or composers depends upon the publication of definitive editions but in turn makes possible larger studies of stylistic trends. In both cases also, a knowledge of larger historical trends will reciprocally deepen our analysis of individual works and improve our critical editions. Because of this reciprocal action between the particular and the synthetic phases of scholarly activity, we must not be overcautious in undertaking studies in the history of ideas; without the perspective and the context these will provide for individual investigations, the analysis of a particular treatise will lack interest and historical value.

Thematic studies that trace typical conceptions and topics through the treatises presently available are the stepping stones to the general history of theory. Only a few such investigations have so far been made: of the concepts musicus and cantor, of the way music has been divided into celestial, microcosmic, and audible types, and of the concept of musica ficta, for example; articles and monographs on ideas of this kind are an area of the history of theory that must gradually expand during the next few decades. Related to this, and vital to the methodology of the field, is a knowledge of types of musical treatise and types of theory. It is clearly essential to understand the function and tradition of a theoretical work before we can begin to deal with it. We must know its genre and purpose, whether it is speculative or practical, part of a university introduction to philosophy or an encyclopedia for the cultivated layman, directed to singers, composers, or theoreticians, concerned with the musical system or the aesthetic properties of individual compositions, a

professional explication of compositional techniques then current or an imaginative endeavor to extend the boundaries of style. Types of treatise are determined not only by function, but also by types of theory, which needless to say, change in the course of musical history. The most familiar general classification of the past was that of speculative and practical theory. In a valuable discussion of this problem in the book Musicology, Professor Palisca presents a suggestive typology that would seem to have a rather general historical applicability. The functions and genres of older theoretical works manifest a bewildering variety, but that of course does not make it impossible for all the species to fall into a few basic genera. The question is bound up not only with the history of ideas and trends, but with the very definition of our field and what it is to include. Only a knowledge of the changing types and topics of theory will enable us to mark off our subject-matter from such neighboring and indeed overlapping fields as musical philosophy, aesthetics, or performance practice.

The interrelation of the history of theory with neighboring disciplines is perhaps the most interesting problem we have to confront, but it can be considered fully only after the history of theory has gotten well under way. That this field is related to general intellectual history, to the philosophy and aesthetics of music, to the history of musical style, and to analytical theory itself will scarcely need demonstration. Indeed, one of the difficulties of the field is the demands it makes on the student by way of a diversified knowledge of the history of mathematics, philosophy, acoustics, and psychology, to mention only a few of the interrelated disciplines that come to mind. For our present purpose, the connections that seem most important are those to style and to analytic theory. As far as style is concerned, it is generally maintained--and doubtless correctly--that the history of theory is an important adjunct of the history of style. If a theoretical treatise reveals, for example, that the third is regarded as a dissonance, or tells us that the voices of a composition are to be written one after the other, we certainly secure some insight into the musical perception of the time and thus comprehend the style more correctly. And it seems certain again that if we study Wagner's Opera and Drama we will deepen our comprehension of the style of the early parts of the Ring of the Nibelungen. As far as speculative theory is concerned, however, the relation to style may be quite elusive,

or even apparently non-existent. Does it have any bearing on the style of the time, for example, when we read in a medieval tract that the Dorian mode is ennobling, that the types of music are mundana, humana, and instrumentalis, or that triple prolation is called perfect because three is a perfect number? The obvious point to be made is that the relation of theory to style varies with the kind of theory we consider. In general, however, the theoretical tracts of a time will not constitute a comprehensive rationale of the musical styles simultaneously current, and it is for this reason that the history of theory must be supplemented in the study of style by the analytic theory of the musicologist, which indeed is an integral part of the stylistic analysis of older music. It is especially interesting that the questions we ask about the music of the past are in general not coincident with those asked by the theorists of the time. That does not mean that our questions are mistaken ones, or should not be asked: it is just that from our station point in time, we legitimately have a changed comprehension of older styles. Indeed it is often surprising to find theoretical tracts silent on the very issues we regard as important. What makes a work cohere? what are its internal tonal relationships, its reliance on planned harmonic succession, linear continuity, or rhythmic recurrence? Or again, what factors did the composer consciously manipulate, what was important to him in constructing the work? By refusing to answer our questions, the history of theory compels us to recognize that our approach is properly a dual one: that we are equipped with our own theoretical interests as well as with a knowledge of past theoretical conceptions. Thus the history of theory will deepen our stylistic analysis by adding a new dimension and helping us comprehend music as it was known in its own time. In addition it will correct the analytic theory we apply in studying the history of style by destroying its pretensions to absolute validity and suggesting that we compare our analytic concepts and techniques with those of the past, and carefully consider their range of applicability.

In sum, what we should aim at initially during the next decade are comprehensive inventories of theoretical sources. Along with this, but continuing for a period of at least twenty years, we must undertake the publication of a representative number of critical editions of manuscript and printed treatises, selected in order of importance and executed according to uniform standards that include translations as well as

detailed annotations. These editions should be accompanied by work on a specialized terminological dictionary, and followed at a reasonable interval first by interpretive studies of individual tracts and later by thematic studies of particular conceptions. If activities of this sort have made sufficient headway before the end of the century, we may look approximately to the year 2000 for some well founded general histories of theoretical trends and for a more adequate comprehension of the province and significance of the history of theory, particularly in the light it casts on musical philosophy, aesthetics, and style.

UTOPIAN PROPOSALS

Lewis Lockwood

In the course of his highly original though somewhat unusual history of music, Jacques Handschin remarked on what seemed to him the curious rise of musicology in America. "... in America," he writes, "... as a result of the World Wars, a type of 'Musikwissenschaft' has come into existence that is very promising but which, in accordance with its environment, must be provisionally regarded as an entirely local and temporary affair." Whatever else this statement may be, it is certainly reassuring. It reminds us that even though we may be unequally gifted in understanding the musical past, we are all about equally expert at prophesying the musicological future. For, whatever American musicology has been over the past twenty years or so, neither its activities nor interests have been precisely local, and its hold on existence seems to be a little better than temporary. No doubt for many reasons both internal and external it has grown at a startling rate in its numbers of practitioners, its resources, and its circles of influence. It also seems to have reached a point, most recently, at which a considerable ferment of introspection has set in, an internal phenomenon only partly related to that external criticism which seems always to keep the walls of the musicological kingdom under steady but quiet siege. Inside the walls, the most far-reaching attempt at self-examination is, of course, the recent book Musicology by Messrs. Harrison, Hood and Palisca, to which I would add the various reviews of the book by a number of us, including Messrs. La Rue, Lippman, and myself. We have also had some other recent and eloquent expressions of opposing views as to what musicology is or might be--suffice it to mention the names Kerman and Lowinsky to all readers of the Journal.

To sum up adequately even a few of the observations embodied in these statements is not only impossible in limited time, but also, happily, unnecessary, since many here will be thoroughly familiar with their lines of argument. All that I am concerned to do instead is to underscore some consequences of the very presentation of these views, and to make a few Utopian proposals for the future.

To begin with, it should now be more obvious than ever that there is no single thing that is musicology; no single type of research or method or point of view that can adequately define the whole of musicology in its various phases. Instead there is a plurality of musicologies representing a wide spectrum of diverse interests, methods, areas, periods, and forms of presentation. In itself this is nothing new. It has essentially been so since musicology in any formal sense first came into existence. But it surely is more obviously and more emphatically true now than it has ever been before. The division is not only an informal division of labor but in part a formal division of groups, working in separate compartments at separate tasks, and, at the extremes, reporting to separate societies.

All this is not even to mention that far more vast and significant problem--namely, the relationship of the various musicologies to other branches of the musical and non-musical intellectual worlds. To speak of relationship here is really Utopian, considering the many gaps in communication and education that need to be bridged. Surely no one here needs any reminder of the seriousness of that cluster of problems. My only concern for the moment is with the internal situation, and here I would bring the reminder, however commonplace, that in its essential course of development musicology is probably not different from any of its neighboring fields of scholarship or intellectual inquiry. I mean this in the sense that its growth is inevitably being accompanied by two concentric tendencies: one towards ever-expanding inclusiveness of interests and subjects, and the constant extension of the field as a whole; the other, towards the populating of this larger space by greater specialization of interests and work on the part of individual scholars. While most people regard expansion as being virtuous, almost everyone agrees that specialization is dangerous. Yet surely it must be obvious by now that a substantial degree of specialization is an inevitable consequence of the very premises on which a professional field of inquiry must rest, among them that its primary concern is that of building a cumulative core of knowledge and understanding of the objects and activities it studies. Every scholar knows what it costs him to really plumb a particular problem to its depths. And if any of us forget at times that the commitments of scholarship are exactly the same as those of "science," in the sense of "Wissenschaft," we should take heed of this description of such commitment by Max Weber, in a famous lecture entitled "Science as a

Vocation":

> One's own work must inevitably remain highly imperfect. Only by strict specialization can the scientific worker become fully conscious, for once and perhaps never again in his lifetime, that he has achieved something that will endure. A really definitive and good accomplishment is today always a specialized accomplishment. And whoever lacks the capacity to put on blinders, so to speak, and to come up to the idea that the fate of his soul depends on whether or not he makes the correct conjecture at this passage of this manuscript may as well stay away from science. He will never have the "personal experience" of science. Without this strange intoxication, ridiculed by every outsider; without this passion. . . according to whether or not you succeed in making this conjecture; without this, you have no calling for science and you should do something else. For nothing is worthy of man as man unless he can pursue it with passionate devotion. [1]

To this I had better add a couple of qualifying remarks at once. The first is that every specialization in the narrowest sense bears along with it some larger area or context within which the area of concentration can be fitted. The second, equally clear but nevertheless important, is that the further any of us go along certain paths of specialization, the more we feel the need to keep our lines of communication open to the rest of the professional world, to others working in other parts of our constantly expanding field, and to adjacent disciplines. In addition, of course, there is the continuous need for the broad presentation of a view of the whole, even to the layman, while inevitably this form of communication will be constantly outpaced by events and discoveries and reformulations taking place in the interior world of specialized scholarship.

My main concern is with the lines of internal communication, and here the need is clear for progress reports or reviews of the state of research in given areas, made on a reasonably periodic basis and, above all, subject to criticism. Surely it is a sign of the times that such reports are extremely hard to find, even in well-populated fields such as Renaissance music, or any of its subdivisions. To this let me add that, several years ago, when I first took on the editing of the Journal of

[1] Max Weber, "Science as a Vocation", in From Max Weber: Essays in Sociology, ed. and tr. by H. H. Gerth and C. Wright Mills (New York, 1946)

the Society, I attempted to elicit several such reports from a number of scholars. Everyone to whom I turned replied to say that this was a splendid idea; and everyone also found himself too much engaged with other things to take it on.

The leitmotif of simultaneous expansion and specialization brings me to those few goals that I should like to try to formulate as Utopian proposals.

First, the problem of internal communication within various fields of musicology ought to be faced squarely and dealt with officially. There are, of course, groups of scholars in the same or closely neighboring fields who are in communication with one another, and in many of these such communication must of course be international, as it should be. But there are many areas of research in which American scholars participate in sufficient numbers and strength to suggest the value of organized colloquia or professional seminars dealing with specific problems and topics. The Isham Library Conferences have provided a small-scale model of what I have in mind. The ideal place for the kind of assemblage I mean would be a national meeting of the Society. At present, the basic form of communication we have is that of the solo performer, either giving a lecture or publishing an article or a book. If the latter, he must wait, sometimes years, for reviews, and if they are only favorable then he learns all too little from them. After a lecture, on the other hand, his words may elicit some immediate praise or blame, but in neither case is the setting well designed for the give and take of considered discussion. Accordingly, I would suggest that the Society itself take the lead in proposing that at least one session during several consecutive annual meetings be devoted to special topics discussed in simultaneously conducted forums by circles of interested specialists, with or without an audience. I stress "several consecutive meetings" to forestall the chance that a less fortunate debut could spoil a second try. And I would further suggest that the number of such groups to be accomodated be as large as possible, in order to permit the topics discussed to be as narrow as possible. Ideally, too, the discussion leader should never be the same person twice.

What might emerge from such colloquia is what seems to be lacking in a number of fields, despite exceptions here and there: a sense of active community of interest and the regular opportunity for free and open criticism of existing dogmas. All too often, individual scholars in our field--as no doubt in every field--tend to put the

individual revelation far ahead of the communal exchange of ideas, and from time to time we are all tempted to stick by a given set of ideas because they are ours rather than because the whole nature of the current evidence compels us in good reason to believe in them. Such an officially sanctioned type of colloquium, aiming at open exchanges of material, of ideas, of beliefs, of theories, and of prejudices, could only be fruitful. Even if it tends to look like the partial conversion of a free enterprise system into a kind of scholarly socialism, it would surely do more good than any number of articles or speeches calling for a new view of the entire direction of what is, I think, mistakenly alleged to be a "single" field.

My second proposal may be less radical in one sense, perhaps more so in another. I mentioned earlier the inevitable expansion of musicology into wider spheres of research. It is clearly in keeping with the nature of the field that it has expanded in two dimensions: in its span of chronological inclusiveness and in its geographical scope. Starting out a century ago from areas that once appeared remote (the 16th to 18th centuries) it branched out progressively into much earlier and, to a far lesser extent, later periods, while at the same time ethnomusicologists explored music of regions increasingly distant from our traditions. Of all this the enormous fruits are obvious enough. But we need an occasional reminder that the chronological and geographical boundaries are not the only ones musicologists and music historians must cross, and that the supposedly more "familiar" fields are familiar only to very limited degrees and within very limited terms. What I am propounding is the familiar thesis that the terms of music history are not only historical, just as those of musical ethnology are not only sociological--both are inevitably entangled in conceptual problems in the very nature of their primary subject, which is neither history nor ethnology but music.

So my "proposal" here, if it can be called one, is not practical at all but entirely ideal: it is for greater recognition by musicologists of the theoretical basis and character of our own work, and of the intimate connection between method and theory in the study of music, just as in other fields of intellectual inquiry. The surprising thing about what I am proposing is that no one seems to seriously disagree with it, yet very little seems to happen to further its realization. In reviewing the Harrison-Hood-Palisca Musicology I argued that the dimension most neglected in the book was

that of the development of speculative and analytical theory over the last half-century.[2] This development has not taken place outside of all musicology; but it has substantially taken place outside American musicology. It seems to me to be the direction in which a good deal of future musicological work will turn--not because I say so or because anyone says so, but because it represents an open dimension of our field in which significant progress can be made towards our implicit goals. It is, in any case, not so much a matter of introducing the new as of recognizing, diplomatically and intellectually, an area in which deep and rich explorations have already been made. In saying this I am not proposing that cultural-historical or sociological aspects of music history or ethnology be diminished in cultivation--I scarcely think they will be. Instead, the field as a whole is likely to continue its growth, and we along with it; nor is there any reason why new dimensions should not appear alongside established ones within an expanded professional context.

The word "professional" brings me to my last Utopian prediction--that the general direction of musicology is towards a more precise identity as a wholly professional field of activity. Claude Palisca rightly objected in Musicology that when the term "musicologist" passed from being a scarlet letter to being emblematic of a certain prestige, amateurs of all types began to use it: "musical journalists and essayists, choral directors, lutenists, organists...folk-song collectors and singers, biographers of musical personalities, 'classical disk-jockeys', record-jacket authors, instrument builders, and others."[3] The point is obvious, yet the problem is no different from that of other fairly established professions whose margins are populated by those who desire the status but shun the work. Part of the problem, of course, is that of defining what a musicologist is and does, and then of defending the implicit professional claim against tacit impeachment. In a recent issue of Daedalus devoted to the professions, the sociologist Everett Hughes described professional activity in this way:

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[2] Perspectives of New Music, III/1 (Fall-Winter 1964) 125.

[3] Musicology (Englewood Cliffs, 1963), p. 118.

> Professionals profess. They profess to know better than others the nature of certain matters, and to know better than their clients what ails them or their affairs. This is the essence of the professional idea and the professional claim... The professional is expected to think objectively and inquiringly about matters which may be, for laymen, subject to orthodoxy and sentiment which limit intellectual exploration... A professional has a license to deviate from lay conduct in action and in very mode of thought with respect to the matter which he professes; it is an institutionalized deviation, in which there is a certain strain toward clear definition of situations and roles... These characteristics and collective claims of a profession are dependent upon a close solidarity, upon its members constituting in some measure a group apart with an ethos of its own. This in turn implies deep and lifelong commitment. A man who leaves a profession once he is fully trained, licensed, and initiated, is something of a renegade in the eyes of his fellows; in the case of the priest, even in the eyes of laymen. It takes a rite of passage to get him in; another to read him out... To be sure, not all occupations called professions show these characteristics in full measure. But they constitute the highly valued professional syndrome as we know it. [4]

Surely the rest is obvious. What musicologists profess and should profess is to know better than laymen and better than other musical professionals not simply dates, manuscript numbers, and arcane terms, but the nature of the music which these things document. As the field develops we shall need increasingly to stress that musicological training, as Oliver Strunk once put it, comes primarily from the study of scores, not books. In that sense the tendencies I mentioned before--the expanding nature of the field and the increasing emphasis on its theoretical dimensions--should combine to strengthen and solidify the kind of professional claim musicology aspires to make. On that note of aspiration, I rest my case.

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[4] Daedalus, "The Professions" (Fall 1963) 655ff.

STYLISTIC CHANGE AND THE HISTORY OF IDEAS

Claude V. Palisca

In looking ahead to this symposium, I tried to conjure up a picture of what the pursuit of musicology may be like in the year 2000. It is a picture I contemplated with mixed feelings. The scholar sits in his study before a cathode ray tube, dials a few numbers, and sees lit up before him any page from any manuscript or rare book he requests, and by pushing a button receives a copy in true colors out of a slot. The pleasant research trips to Europe and other places that once musicologists persuaded themselves, foundations, faculty committees, and sometimes even the Internal Revenue Service as absolutely essential have been rendered quite superfluous. Field work in ethnomusicology has similarly been wiped out, because serious composition from central Africa to Iceland follows the same international computer-assisted technique, and popular music the world over suffers the short life-cycle of the same dance craze. Field work has become the exclusive preserve of astro-musicologists, true traveling fellows who finish a book or Ph.D. thesis on the trip back.

I find it less depressing, on the other hand, indeed quite exciting, to consider the immediate future. So, with the permission of our chairman, I shall focus on this briefly, and particularly on one problem that has concerned me for a long time: the role of the history of ideas in stylistic change.

It has been stated over and over that a central task of musicology is style criticism. Manfred Bukofzer went so far as to say, "style criticism must be recognized as the core of modern musicology."[1] Much of the work of active scholars today is directed to this end. Where style criticism stands in relation to the ultimate goals of musical scholarship, there is less agreement. Frank Harrison has said that "a close analysis of the composer's musical thought and style in the light of technical

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[1] The Place of Musicology in American Institutions of Higher Learning (New York: The Liberal Arts Press, 1957), p. 30.

and aesthetic principles of his day" should be a means to the re-creation of the music through performance and to a reconstruction of the social context of musical expression.[2] Joseph Kerman makes style criticism a servant of criticism in general, the prime goal being elegant interpretations of the great works of the great masters.[3] Edward Lowinsky regards style criticism as an important component of a host of coordinate disciplines that add up to the universal and humanistic field that is musicology. He would have us do, according to our talents, whatever tasks we are able, as well as we can and not worry about the hierarchy of disciplines.[4]

Still, we cannot help worrying about ultimate goals, and we do need them to have a sense of value and proportion about our digging. Is every uncovered archival document, biographical fact, unpublished musical work worth discovering and reporting? To be sure no one can ever predict which fact or piece will become important. Yet a scholar, particularly one of the coming generation about which we are speaking, must have some sense of a purpose beyond the accession of solid facts. Particularly when statistical data are easily gathered and analyzed through computers, the scholar needs to know when to stop, to recognize when the point of diminishing relevance is reached. Only when statistics are used to solve problems rather than to compile information can we justify the expenditure of precious computer seconds and keypunchers' long days.

Bukofzer saw style criticism as an aspect of the history of ideas: "The description of the origin and development of styles, their interrelation, their transfer from one medium to another, is the central task of musicology. Only the stylistic method will permit a correlation of music history with the history of ideas and the general cultural history of mankind, if such correlation is to be more than a loose comparison

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[2] Harrison, Claude Palisca, and Mantle Hood, Musicology (Englewood Cliffs: Prentice Hall, 1963), pp. 74-80.

[3] Joseph Kerman, "A Profile for American Musicology," Journal of the American Musicological Society, XVIII (1965), 61-69.

[4] Edward E. Lowinsky, "Character and Purposes of American Musicology, A Reply to Joseph Kerman," Journal of the American Musicological Society, XVIII (1965), 222-34.

or an abstract parallelism."[5]

Bukofzer wished to see a history of musical styles that could be located in the more general history of ideas and culture. Slowly we have been accumulating such a history, but we have neglected the other side of the equation, of which Bukofzer showed he was aware: musical style is also a product of ideas and cultures.

While criticism may contribute to the history of styles, to find the origins of style is not the critic's business. The critic--whether the style critic of Bukofzer or the stylish critic of Kerman--aims to enrich the meaning of a work for others by his interpretation. His method is essentially descriptive, his product, critical, analytical, perceptive, and enlightened description, perhaps, but always description. Descriptions of musical styles, arranged in chronological sequences, with some attempts at showing evolutionary connections--these pass today for histories of style. But they ignore one of the great challenges of history, to explain why certain events occurred, not just when, where, and how. The causes of change in styles are the great open questions of music history.

The neglect of causes comes partly from our erstwhile passion for being "scientific." It is easier to be scientific in ferreting out facts and arranging them than in explaining them. But this is accepting the premise of a rather naive and retarded view of science as measured observation. Much modern science consists of unproven hypotheses that happen to work.

I propose that we construct hypotheses about the major stylistic changes. Some of the components of these hypotheses have been investigated for a long time: autonomous musical factors such as the influence of composers with strong and inventive personalities; improvements in instruments; the search for perfection of form; exploration of the tonal medium; and so forth. We are relatively familiar with some of the non-musical factors: changes of social function, or liturgy and religious attitudes; geographical movement of musicians; tastes and economic condition of patrons; and other social, political, and economic facts. Information concerning these matters has been used largely to establish a context for the careers of composers rather than to supply the determinants for stylistic change. Because

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[5] Bukofzer, The Place of Musicology, p. 31.

of the emphasis on major composers, the information is scarcest where it is most needed, for the transitional periods. These, the very keys to the dynamics of stylistic change, are neglected in the effort to define the mature styles.

Perhaps the most neglected and misused resource has been the history of ideas. Philosophical positions, beliefs about the physical and spiritual effects of music, pseudo-scientific or scientific theories about the hearing or acoustics, and similar matters have great relevance for music history, as has always been appreciated. But their exploitation has suffered from what I shall call the Zeitgeist fallacy. The Zeitgeist is the sum of spiritual and intellectual expressions at a certain moment. An art work of a particular time is supposed to express its Zeitgeist, which in turn is supposed to explain the art work. For example, the Sturm und Drang movement, it is said, helps to explain the character of Haydn's music in the 1760's and 70's. Descartes' treatise on the passions is said to help explain the preoccupation with the passions in baroque music. The fallacy here is to explain an event with a contemporary one. This is analogous to maintaining that the existence of Pierrot lunaire explains the existence of Sacre du printemps. Both probably have a common cause, but the first has no causal connection with the second. Similarly Sturm und Drang and Haydn's music may both have some connection with the sensationalism of the earlier half of the 18th century, as Descartes' treatise and the music of the passions are both related to the revival of Aristotle's Rhetoric and Poetics in the 16th century and the consequent literary attitudes in that century.

One of the exciting opportunities that awaits us and our successors is to uncover the ideas that nudged the consciousness of composers great and small. Perhaps no category of musical sources is so rich in unexplored or barely explored documents as writings about music, except, of course, writings that touched writers on music. Who really knows what Boethius or Guido thought and how this affected their successors? What made them think as they did? Or to take some later examples, the voluminous correspondence of Pietro Aron, Giovanni del Lago, Giovanni Spataro, and others still lies untranscribed and largely unknown. The writings of Giovanni Artusi, so rich in insights about his time and its music, are known only through dim half-truths scattered in the literature on Monteverdi. The works of Marin Mersenne

alone could provide a team of scholars fuel for a lifetime of research. And so on into the 18th and 19th centuries, where writings of composers and critics have hardly been tapped except for aphorisms about their rivals or pet-peeves and similar anecdotal parlor fare.

The history of ideas can provide only one strand of the complex of causal connections that can account for stylistic change. It is an important strand, for every inventor and creator is a thinker, even if he is not always an intellectual. But the chain of ideas is only one of a complex of intricate patterns of stimulus and response. The future musicologist may well turn to constructing models, as his fellow scholars are doing in linguistics, social sciences, and natural sciences. Through such models, perhaps with the help of computers, he may learn to understand the dynamic relationships that exist in every musical situation and to measure the forces at work.

In short, after all the thematic indexes have been computerized, and every statistic is in about every major composer, we shall still have much food for musicologists and their machines. Much work remains to be done. The chances are that the physicists will have their general field theory before we achieve ours.

MUSICAL BIOGRAPHY AND THEMATIC CATALOGUING: TWO OPPOSING ASPECTS OF MUSICOLOGY IN THE 21st CENTURY

Franklin Zimmerman

General concern about the nature, purpose and scope of American musicology has in recent times produced various definitions and reformulations in books and articles, even a few controversies. Somehow confusion does not yet seem to have cleared entirely. Discretion, and the injunction to be brief forbid my attempting another formulation here, even though a working re-definition of American musicology underlies the notions I shall entertain. Believing with Aldous Huxley that "Ends are apes', means are man's," I shall make no Nostradamic forecasts, nor Orwellian predictions, but shall limit my remarks to possible improvements in various phases of the present musicological discipline up to, say, about 1999.

Though I cannot cope with the need for definition, I ought at least to hazard a preview of what the musicologist may be doing in the 21st century. Then, as now, he will very likely be a teacher, a musician and a writer, whatever other duties he may have to assume. As Frank Harrison has pointed out[1] sociological considerations probably will form an important part of future musicologists' concern. In music, as in all else human, man will still be the measure of all things.

Approaching the second Christian millenium, already we can see the main social problem which will beset mankind: there will be too many of us--too many even here in the land of opportunity, if we may believe Lincoln and Alice Day, who give such pessimistic views on this and related problems in Too Many Americans.[2] In America, most of the 'too many' will have too much empty leisure. In spite of possible successes resulting from the recent passages of the Higher Education Bill, or from

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[1] Frank L. Harrison, Mantle Hood and Claude V. Palisca Musicology (Englewood Cliffs: Prentice-Hall, 1965) p. 84.

[2] Lincoln H. Day and Alice Taylor Day Too Many Americans (Boston: Houghton Mifflin, 1964).

the activities of the National Council for the Arts in Education, it is unlikely either that we shall have cured the present vicious cycle of "drop-outs and delinquency", or solved the general cultural dilemma in which we live.

How will musicologists then be working? All their activities, particularly teaching will be conditioned by these major sociological problems and by the lesser difficulties which may spring from them. If our demographic prophets are predicting accurately, and if the H. E. B. revolution and N. C. A. I. E. programs are effective, liberal arts classroom traffic will be heavy. Hence a dynamic equilibrium between demands for a general, broad-based liberal education on one hand and specialized technical competence on the other which will be even more difficult to maintain than at present. Unless something is done, not only will there be deeper trenches separating so-called applied, theoretical and literary areas of musical study, but music appreciation will have become a completely separate discipline, and musicology, though it may have enlarged its crumbling ivory towers, will not have escaped from confinement to these.

Indeed, the musicologist's dilemma may have worsened considerably by then. For surely by the year 2000 historical musical research will have reached the condition now faced in M. L. A. disciplines. By 2001 A. D. increases in the number of musicologists and advances in technical proficiency should have long since depleted musicological research sources, if we are any good at all. (That is to say, by then R. I. S. M. ought to be merely a convenient guide to research achievements.) Already musicology is turning to new modes and resources of research, particularly here in America where the European model has not worked very well anyway, for lack of its basic pabulum: archival matter. By the year 2000 the formal coordination of systematic and historical musicology will have become a reductio ad absurdum, particularly with the computer at hand to lighten the labor of analysis, correlation, and bibliography, and Riemann's five sub-disciplinary fields will have merged.[3] As internal partitions disappear more frontiers will have vanished in music, as everywhere else. At least such will be the case if we continue to proceed within the profession as it is

[3] Acoustics, tone psychology and psychology, musical aesthetics, theory of composition or performance, and music history.

now structured. But this need not be. Being forewarned we are forearmed. We could continue to be governed by the Victorian "pigeon-hole" administrative outlook we have inherited, assigning to every person his special area and skill in the academic assembly line. But this old-fashioned division of musical activities into bailiwicks and precincts is so wasteful, so fraught with destructive contention and so futile especially from the student's point of view that it cannot long continue. We might go on encouraging highly specialized skills in one small area or another of either systematic or historical musicology, leaving the "generalist" at the bottom of the totem pole. But I do not believe that we will thereby improve the quality of teaching, or raise the level while increasing the breadth of scholarly research in the profession.

On the other hand we might take a lesson from recent developments in the natural sciences, where it has become clear that an accurate understanding of the origins and early evolution of life on earth cannot be achieved via the fragmentary highly specialized approach which has prevailed in the past. New data on climatic and solar conditions pouring in as man has gotten into outer space have given rise to the first important general reformulation of evolutionary theory since Darwin. As John Lear, Science Editor of Saturday Review has pointed out in the issue for May 7th, 1966 (p. 29): "Generalship, as opposed to specialization...provided the scope needed for a definitive, comprehensive new formulation."

This, I submit is something we musicologists must look to. Likewise in music, and especially in musicology, we shall encounter ever more pressing need for the benefits of the larger view. We want the generalist who not only understands Pierre de la Croix as fully as Pierre Boulez, but who also can cope with all the intricate skills of systematic musicology without losing active contact with basic and essential musical skills themselves. That is to say we need to breed a race of musicians equally at home in the research cubicle, in the archives of foreign and domestic libraries, in the class-room and lecture-hall, who can mount or effectively take part in live musical performance.

This last point is most important of all. For one much needed general rehabilitation must create a system of musical disciplines orbiting around some central, indeed quintessential skill. Fortunately the choice is obvious to everyone: the one

musical skill which can enliven and illumine all other disciplines and skills as no other can is skill in the intuition and interpretation of musical thought. That is to say fluency in the language of music. (Although the subject would be fascinating, there is no time to argue about the optimum skill; but solfeggio is at the center of my own pet scheme.)

Let me illustrate these remarks by turning to special phases of musicology in musical biography and thematic cataloguing. This antipodal pair will actually be joint pursuits only when he who writes or compiles them adheres to strictest musical logic. This of course would imply complete control of research data, which will be possible only under those propitious conditions which will be established when all sources have been searched out and made available.

Most existing musical biography is bifurcated by the old dichotomy which produces on the one hand the stuff of "life and times," on the other, critical evaluation of compositions. The former relies upon techniques borrowed from the archivist, the bibliographer, the genealogist, the cultural historian. The latter depends primarily upon analysis of styles and forms--usually traced according to a roughed-in chronology which, often as not, includes more than a few suspect, if not downright spurious works--and secondarily upon ancillary research sciences such as calligraphy, papyrology, etc.

With notably few exceptions in modern biography the mixture of biographical and aesthetic data is anything but homogeneous, if indeed there is a mixture at all. Subtler integration of details oriented to either pole of the dichotomy is seldom attempted except perhaps in certain studies in which, through fictive license the author bases upon fantasy those parts of his account for which he can produce no facts.

The ideal musical biography, it seems to me, would trace the musical life of a musician in terms of the actual thoughts expressed in his compositions. Here again the subject is too complex for detailed treatment. Let me merely propose that with modern advances in music psychology, music bibliography, calligraphy, papyrology and sociology and ethnology, and particularly with the aid of the high-speed computer the ideal, wholly integrated approach to biography and analytical evaluation becomes realizable. Echoing Manfred Bukofzer's forecast of a history of music written

strictly in terms of musical style, I believe that the musical biographer one day will have at his disposal all the data, and be in command of all research techniques necessary for writing a scientifically grounded account of the musical life of his subject, relegating all extra-musical or para-musical considerations to various peripheries revolving, as it were, around the center of gravity provided by the sounding form and substance of the artist's musical thought.

One absolutely essential tool for such formulation is the full-dress systematic thematic catalogue, a specialized research implement which can be built and perfected only in stages, each of which is complicated by the necessity to serve needs of the general musical public as well as those of the specialist. For general purposes the catalogue need be only a self-consistent comprehensive ready reference to a composer's forms and styles with enough in the way of commentary on archival, bibliographical and biographical sources to give a general idea of the chronological order in which the pieces were composed.

But for the specialist, be he music editor, biographer or music historiographer, the need for pin-point accuracy in chronology and text actually requires that a "proto-catalogue" be compiled, published and used for awhile, even though, to the chagrin of the publisher it serves as the instrument of its own obsolescence. In this stage (represented by the first few editions of most established thematic catalogues) it is essential to devise some efficient system correlating individual works with manuscript and printed sources and providing full chronological and critical commentary. Where possible, actual 'genealogies' of important related manuscripts ought to be sorted out, not only for purposes of judicious collation, but also to provide for accurate chronology, in which time of publication usually gives only an approximate terminal date.

In the ideal thematic catalogue, as in the ideal biography, such paraphernalia ought to be subservient to the central and chiefly operative force of a composer's musical ideas, arranged as nearly as possible in their chronological order. Somewhere along the way in the hyperbolical approach to ideal perfection outlined here, there occurs a transition from the proto-catalogue to the catalogue proper.

The biographical study and the thematic catalogue can therefore be seen as approaches to a definitive understanding of music as it can be observed "at birth",

so to speak, in the context of its creator's life. Refinement and adjustment of our techniques in this area, I suggest, will not only merge these two antipodal approaches, but carry us a long way towards significant re-definition and re-structuring of musicology as a whole. For the merger of the systematic/analytical and dynamic/chronological approaches will affect all our activities and modes of thought.

Thus, with ideal musical biography, ideal music historiography, ideal music teaching, ideal musical interpretation--in short ideal musicology--it seems to me that we are faced with certain quasi-eschatological considerations which though not so drastically final as those which disappointed universal expectation at the first millenium, do allow for optimism, perhaps even a little genuine excitement. When our archival sources are all depleted and the musical past has yielded up all its secrets, our vade mecum will be complete or nearly so. Like lion and lamb, performer and musicologist will lie down peacefully together and harmony will reign. Then may we turn our attention to the green growing edge of our musical tradition. For never yet has music been nurtured and safeguarded in a manner worthy of the oldest and most human of the liberal arts.

These things scarcely can come to be before the 21st century. Indeed, modern citizens of the musical world might well be wise to remember the waves of disappointment which swept over Christian civilization on New Year's Day in the year 1000. Provided that mankind does reach the year 2001 in recognizable condition, he may need yet another millenium to achieve control of himself and his affairs, or to gain mastery over political and sociological forces anything like that he now has over his environment. Because music is one of the subtlest and most intimate of the emanations of the fragile breath of human life--to paraphrase our life scientists--it is unlikely that man's musical condition will flourish until he has gained such control.

DISCUSSION

CHAIRMAN: I have asked Professor Mendel to make some general concluding comments after the participants have had their say.

EDWARD LIPPMAN: I'd like to mention a feeling of my own about stylisitc analysis and perhaps ask Professor LaRue if he doesn't agree with it, since it proceeds from an anti-computer mentality. But my feeling is that this kind of analysis which is projected with computers, as well as we can foresee it, and as a matter of fact the analysis that we've had a sample of on the blackboard, do not deal adequately with style, but rather deal with it as a kind of one-dimensional description of the score or the characteristics of the music which are very objectively present. Whereas if we consider style as it's been described today in a few connections, as growing out of a wealth of ideas and feelings, if we consider a particular work as belonging to a historical field or genre, with a certain type of theme and so on, if we consider the fact that music obviously is experienced and listened to, as well as produced by human beings, it seems to me that style has at least a relation to certain complex structures, a certain duality, something behind or in addition to what the score presents; and in this context the objective must have its setting. And to get at this complex, I think, which is a matter of historical variability, calls for individual interpretation because of the very nature of history. We must inevitably, I would hope, employ the creative aspect of the historian's work, namely, what he selects from this welter of material behind the work with its implications and its historical character. And for the life of me I don't see- and I hope I'm right about it--that this can all be turned into a one-dimensional computer analysis, so that I'm in a sense asking Professor LaRue if he doesn't agree that there are aspects of style--and I think they're important ones--that are beyond the reach of objective analysis either as we see it here on the blackboard or as performed by computers. You're perhaps more optimistic about those techniques than I am.

JAN LaRUE: Considerably. First let me address myself to the idea that a computer

analysis is one-dimensional and that other analyses to which you've referred are multi-dimensional. I feel, myself, that the shoe is rather on the other foot--that the types of analysis to which you refer are personal and subjective and extremely limited, and that the computer analysis, if it's properly managed, will present us with a great variety of choice in our interpretations. Now, I really very much object to your term one-dimensional, since at the outset of my remarks I pointed out that the whole style analysis--the attempts I'm making--is addressed to the complete fabric of music: sound, harmony, rhythm, melody, as they combine in form. And that the whole point of the computers is not that we rely totally on the computer analysis of this at all, but merely that it gives us a very powerful way of correlating any observations that we may be able to set in motion ourselves. Now, I would be the last to maintain that this type of style analysis makes answers about music. My whole point is that style analysis gives us answers in the objective part of whatever we can do with music; and I immediately agree with you that there's a great area in which personal interpretation and subjective interpretation must always be brought to bear. The aspect that I'd like to stress is that we have had no comprehensive treatment of the objective parts of the study of music, and if we can increase our understanding in those areas I think it will help us say something more broadly valid in the subjective areas.

FRANKLIN ZIMMERMAN: I'd like to add a footnote for I feel that the computer is infinitely flexible and variable. It is really. If I may refer to an old fairy tale, it is like the mirror on the wall. You know--you can ask it anything you like. It can only answer "yes" or "no" on any given point; but if you frame your series of questions properly, it will provide pretty good answers.

What I am going to ask is still problematical. That is to say, I'm having lots of fun punching cards at the moment in preparation for a third volume on Purcell (which may come out in the year 2000).

What I'm going to ask it do do, actually, is to support the weakest link in musical research, that is, the human memory. I have some 4000 themes drawn from Purcell's complete works now punched into cards. I am asking the computer to tell me nine different kinds of things about these themes--all nine being leading questions to help fill in large gaps that exist in the Purcellian chronology. This might seem a futile

exercise; but we do not have any good remedy, otherwise. With several notebooks full of statistics comparing musical phrase-lengths with verse-lengths, verbal settings and other kinds of analytical data, I frankly boggle at manipulating so much detail. I can't go into all of that, especially since the computer will do it for me. Already it has done in one minute and one second what I would have had to spend at least a month completing. I thank it, and aim to ask it more questions.

LUTHER DITTMER: I wish to raise a small question about a large issue. We have heard many references to the term "American musicology" as if American musicology is different from any other kind of musicology or even from unqualified musicology. I am not quite sure what the definition of American musicology is--whether it is work done in these United States, or work undertaken by American Nationals, dissertations written for American Universities, or even opuscula devoted to American subjects, or possibly even all works printed in English with the American orthographic and semantic variants. Musicology as it is professed by, for, and concerning Americans does not differ except in details from musicology as it is professed by, for, and concerning Europeans: methodology, purpose, principles, subject matter, types of organization, methods of publication vary only in titles and language, not in substance. On the contrary, musicology itself will be the loser if its university is threatened by even a mild form of nationalism on other than a bureaucratic plane.

Since our colloquy this afternoon involves us in a prognosis for the final third of the twentieth century, I wish to stress that a possible dichotomy between American and European musicology will have to reckon with the development of musicology in further lands--those countries called underdeveloped in contrast to those that might be called overdeveloped. Musicology will develop in such *Entwicklungsländern* as part of a growing opulence. National and regional musicology will rightly deal with the classical and popular music of the country or area. Yet local tradition is but one of the concerns of musicology, and the universal aims and goals of musicology--to know, investigate, evaluate, and narrate music both as a function of the order of things and as part of human conduct--will preserve its international aspect. Even if music is not a universal art, musicology is a universal science.

LEWIS LOCKWOOD: I'd just like to add a footnote on two points that have been raised. One is the computer question. In approaching the question of style analysis and the possibilities of the computer, it seems to me that the future use of the computer can scarcely be a matter of question. The important question that I think one has to ask is: How will it be used? With what limitations? With what purposes in mind? To what degree will its use be an extension of a phase of research that demands it, and to what degree will it in some sense be forced upon categories which it may not quite fit? I surely hope that it will be more the former than the latter, needless to say. But it seems to me also that one should not regard computer analysis as anything more than an extension of procedures that in some rudimentary sense, rudimentary physical or mechanical sense, already exist; or would exist if only human beings were capable, as Franklin Zimmerman points out, of doing in a month what a computer can do in a minute and a half. There exists already a very large number of theories of music which we are constantly using whether we like them or not and, in some cases whether we know them or not, some aspects of which it may be possible to test in part with the help of these devices. Let me just mention, for example, the theories associated with names familiar to everyone here--names like Jeppesen, or Riemann, or Kurth, or Schenker.

Now, regarding the possibility that sources are going to go out of existence. I think this is clearly impossible. It is surely true that the source material of given style periods will tend towards exhaustion as they are more and more fully brought to the surface. But at the same time our whole concept of what the style periods are must also inevitably change, for composers of the present will, after all, in the year 2000 be the composers of the past. We don't now think of composers of thirty years ago or sixty years ago as being unsuitable subjects for musicology. Why should we imagine we'll think so in the year 2000? Accordingly, there will always be more source material, provided there is always more composition. And if at any moment composition gives out, then so much the worse for musicology. Perhaps it had better do so as well.

ARTHUR MENDEL: As I remember it, I was asked to join with a couple of other gray-beards in making some sharp rejoinders to what had been said. To start with the last topic that has been brought up and the one I'm afraid that's going to be brought up many, many times again. It seems to me that the words computer analysis are a

misnomer and that part of the trouble comes from this. I don't think anybody uses the computer to analyze; the computer records data, makes the data accessible, makes it possible for us to manipulate them, and makes it possible for us to analyze them. So I don't think there is any such thing as computer analysis.

As to the question whether style includes elements beyond the reach of objective analysis: It seems to me that the analysis of things which are beyond the reach of analysis is a contradiction in terms, and I don't really think that's what is meant. I agree that there's more to an example like the one on the blackboard than meets the eye. What's more to it is, for example, that doubtless a minor second has a different effect on us in some ways from a major second, and a rising one from a falling one, and so on. These effects are subjective in a sense. But all one could analyze fruitfully would be what the effects on each of us have in common with the effects on each other of us, and perhaps the limits of variation among individuals. And I would think, to pursue the idea that two or three speakers have mentioned, that the close connection of historical musicology with theory, with psychology, with ethnomusicology, with psycho-acoustics, with deep, intensive analysis of individual works, can lead us in the direction that I think even Mr. Lippman really means--to things that are, in a sense, behind the notes, but not so far behind that they're permanently beyond the reach of analysis. How can we compare works which we don't know inside out? We can make superficial comparisons of a large number of works--the larger the number of works, the more superficial the comparisons. Eventually, one could hope that one could make comparisons of an increasingly large number of works which had been analyzed in a much deeper way, and here no doubt the computer may be a tool to help us do so. A style is, after all, what is abstracted, what a number of works have in common. Now, unless one knows what each individual work contains, one can't know what they have in common. One can know a few little features that they have in common and call this a "style,"--temporarily, until one knows more, that's all. I would hope that through the increasing intimacy between historical musicology and musical theory one could get further and further behind the superficial appearance of the notes.

On the question of what "causes" stylistic changes, historians and, I think, philosophers of history blanch at the thought of causal explanation of changes in style. We

all try it; we all make "hypotheses." But a hypothesis is really by definition something you can test, and how can you test these? Now I myself have taken a position quite strongly in favor of constructing hypotheses that one can test and on testing every part of them in as rigorous a way, as scientific a way, as possible. In doing so, I quoted a wonderful passage from an essay on the philosophy of history by Isaiah Berlin in which he said that the materials which science analyzes are thin and discrete objects, discrete phenomena which can be individually measured and tested, but that the materials of history are "thick" in a way that defies this kind of testing. When he was in Princeton in the fall, we spoke a little about this and I asked his whether he didn't think that the "thickness" of history was simply its richness of hypothesis, and that this simply meant that it was endlessly complicated to analyze, but one aspect after another of each hypothesis and one hypothesis after another could be tested. He replied in effect: No, it isn't the richness of hypothesis that makes it thick. What you're talking about is spaghetti, a group of elegantly separate strands of pasta. What I'm talking about is a wonderful soup in which the ingredients have been so mixed that one couldn't possibly separate them out for analysis. I had hoped to find, and I think somewhere in the literature there must be, remarks made before organic chemistry had made strides that it has since made, explaining that it was perfectly all right to be able to analyze carbon dioxide and sulphur nitrate and simple compounds like this, but that organic compounds (say, tar, for example) were simply too "thick" to be analyzed. Now while nothing can be analyzed completely, this claim turns out to be essentially wrong. One can get closer and closer to a good analysis of the most complicated substance. And I would hope that this would be true of music, and, therefore, of style, too.

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Editor's Note

This listing represents perhaps the ninth metamorphosis of a "dittoed," multi-colored, almost illegible ancestor, one tenth its size. The initial "Draft Bibliography: the use of the computer in music and musicology," was prepared for the first *Musicology and the Computer* Symposium in April 1965, by the editor of this volume and Evan Robinson, at the time a master's student at Queen's College.

Gary Berlind, then with the Institute for Computer Research in the Humanities of New York University, in collaboration with Barry Brook, Lejaren Hiller, Jan LaRue, and George Logemann, prepared a much-expanded, computer-printed version entitled "Writing on the use of computers in music." Valuable emendations were provided for this version by Allen Forte, Michael Kassler, Walter Reckziegel, and many, many others. It was distributed at the annual meeting of the American Musicological Society at Ann Arbor in December 1965. A later compilation was printed in *College Music Symposium* VI, 1966. Harald Heckmann published an

abbreviated version as a conclusion to his *Elektronische Datenverarbeitung in der Musikwissenschaft*. New items were compiled thereafter by Heath Ellis Thompson, *RILM* research assistant, and forwarded for publication in the *Computers in the Humanities* annual bibliography.

The present metamorphosis was prepared in mid-1969 with the invaluable assistance of Elaine Lisinsky, a Queen's College master's student. It includes some items from 1970 added in the final proof stage. Items for which abstracts have appeared in *RILM Abstracts* --since 1967--are indicated, by year and number, thus: *RILM* ^{67} *123* . The bibliography is not limited to musicology and the computer, strictly defined, but attempts to embrace all aspects of computer applications to music. When a listing is appropriate to more than one of the above-indicated categories, it is repeated.

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